

MACC WETLANDS BUFFER ZONE GUIDEBOOK

For use with Massachusetts Wetlands Protection Act,
MGL Chapter 131, Section 40



MACC BUFFER ZONE GUIDEBOOK

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1.0 PURPOSE & ORGANIZATION OF GUIDEBOOK

1.1 Purpose

The Massachusetts Association of Conservation Commissions (MACC) Buffer-Zone Guidebook (“Guidebook”) is intended to be the primary source document for Massachusetts Conservation Commissioners seeking information and guidance when reviewing activities in the 100-foot Buffer Zone to Resource Areas regulated under the [Massachusetts Wetlands Protection Act](#) (WPA) and implementing regulations (310 CMR 10.00 et al.), and under local bylaws and ordinances. This Guidebook also analyzes the role riparian corridors play when functioning as buffers to wetlands bordering rivers, streams and other waterways, and provides guidance with regard to regulated Riverfront Areas (see Appendix E).

Several reference documents exist with regard to Buffer Zones in Massachusetts, including [The Massachusetts Buffer Manual](#) (Berkshire Regional Planning Commission for Massachusetts Department of Environmental Protection (MassDEP) 2003) and [Buffer Zones and Beyond](#) (Boyd 2001). Additionally, the New Hampshire Association of Natural Resource Scientists (NHANRS) [Scientific Wetland Buffer Report](#) (NHANRS Legislative Committee 2017) provides a Buffer Zone literature search and report on buffers and riparian corridors. The literature review conducted in preparation of this Guidebook assessed a variety of research papers, literature review papers, textbooks, and reports on buffers and riparian corridors. Based on this literature review, Chapter 2 provides a summary of the science on the role of buffers, including riparian corridors, in supporting wetlands and waters to protect the important functions and ecosystem services that wetlands provide. This includes meeting the challenge of climate change within the regulatory framework of the WPA and potentially under local wetland bylaws and ordinances. Chapter 4 provides a discussion of wetlands and their buffer zones in relation to climate change.

The guidance provided by handbooks and manuals, including this Guidebook, is never intended to replace the legal authority and interpretation of the WPA and associated regulations. However, the regulations do not provide performance standards for 100-foot Buffer Zones but require conservation commissions to make decisions in accordance with the role that Buffer Zones play in protecting the Interests of the Wetlands Protection Act that are associated with regulated wetlands and waterways, and in accordance with regulatory criteria at 310 CMR 10.24(1) and 10.53(1). The science and analyses provided in this Guidebook are intended to assist conservation commissions in their efforts to evaluate Buffer Zone projects on a case by case basis in this regulatory context, as well as in the context of local bylaws and ordinances.

A landowner’s level of understanding of the role of the Buffer Zone in contributing to the Interests of the Wetlands Protection Act can be a significant component in determining how the Buffer Zone is maintained over time and can lead to greater or lesser protection of the adjacent Resource Area. In this regard, the Commission may want to consider opportunities to provide community education, including making this Guidebook and other related resources available, and to encourage activities that benefit the ecological functioning of the Buffer Zone and Riverfront Areas, such as restoration projects and clean-up work.

1.2 Terminology

Various terms are used to refer to the land adjacent and functionally linked to wetlands, waterways, and water bodies. For this Guidebook, the capitalized terms **Buffer Zone** and **Riverfront Area** refer to regulatory areas defined in the WPA regulations under 310 CMR 10.04 and 10.58 respectively. In the

scientific literature, related non-regulatory terms include buffers, other types of buffer zones defined differently from the Massachusetts regulatory definition, riparian areas, riparian corridors, and riparian zones. For simplicity, this Guidebook will use the terms **buffers and buffer zones** (i.e., not capitalized) when referring to land adjacent and functionally linked to wetlands, banks, waterways (including both intermittent and perennial streams and rivers), water bodies (including ponds, lakes, and ephemeral pools), but not restricted to the first 100 feet from the boundary of a regulated resource area (e.g., Bordering Vegetated Wetlands). This term includes riparian areas, zones, and corridors, which, again for simplicity's sake, will be referred to collectively as **riparian corridors**, and are not restricted to either the first 100 feet from the top of Inland Bank or 200 feet from the Mean Annual High Water of a perennial stream (e.g. Riverfront Area). The authors of this document recognize that others make distinctions between riparian areas, zones and corridors, but find that different entities use the terms differently, and that for this Guidebook, one term is sufficient.

Additionally, when capitalized, the term **Resource Area** refers to wetlands, waterways, water bodies and riparian corridors that are subject to regulation under the WPA. When **resource area** is not capitalized, it refers more generally to natural ecosystems and ecological resources. The WPA protects eight Interests or ecosystem services/functions that Resource Areas provide, listed at [310 CMR 10.01\(2\)](#), which will be referred to herein as **Interests of the Act**. In addition to the Interests of the Act, wetland resource areas provide other ecosystem services and functions that are not included as specific Interests of the Act or have previously not been understood well enough to be associated with the Interests of the Act. Chapter 4 of the Guidebook provides further explanation of additional ecosystem services and economic valuation of wetland resource areas, buffers and riparian corridors. The Millenium Ecosystem Assessment (2005) defines **ecosystem services** as benefits that ecosystems provide to humans. Readers may be more familiar with the terms **functions and values**, so both terms are used in this Guidebook.

Appendix A provides definitions for additional terms found in this Guidebook, as well as a list of acronyms/abbreviations.

1.3 Regulatory Overview and Key Definitions

1.3.1 *Massachusetts Wetlands Protection Act*

Massachusetts was one of the first states in the nation to regulate wetlands. For the first several years of protection (1957 – 1974), the state administered the WPA and its antecedents without any regulations. Procedural regulations were promulgated in 1974. New, performance-based regulations were issued in 1978 to protect coastal wetlands. In 1983, similar regulations were promulgated to cover inland (or freshwater) wetlands. These regulations clarified jurisdiction and created the concept of a 100-foot regulatory “buffer zone” around resource areas. [Protecting Wetlands and Open Space: MACC's Environmental Handbook for Massachusetts Conservation Commissioners](#) provides a detailed history of wetlands and open space protection in Massachusetts.

More specifically, according to 310 CMR 10.04, Buffer Zone means:

“... that area of land extending 100 feet horizontally outward from the boundary of any area specified in 310 CMR 10.02(1)(a).”

WPA regulation Section 310 CMR 10.02(1)(a) specifies that the areas with 100-foot Buffer Zones are any bank, freshwater wetland, coastal wetland, beach, dune, flat, marsh, or swamp that **borders on** any estuary, creek, river, stream, pond, lake, or the ocean.

The WPA regulations established a 100-foot Buffer Zone around all Resource Areas except Land Subject to Coastal Storm Flowage, Land Subject to Tidal Action, Land Under Water Bodies or Waterways, Land Subject to Flooding and Riverfront Areas. The Buffer Zone is not a Resource Area, but apart from certain minor projects, Commissions may regulate and condition work in the Buffer Zone that may affect a Resource Area. Put another way, the Commission's responsibility with respect to activities proposed within the Buffer Zone is to ensure that the proposed activities will not alter a Resource Area. Figure 1 (inland wetlands) and Figures 2A and 2B (coastal wetlands) illustrate Resource Areas regulated by the WPA and associated regulations, and Figure 1 includes inland wetland Buffer Zones.

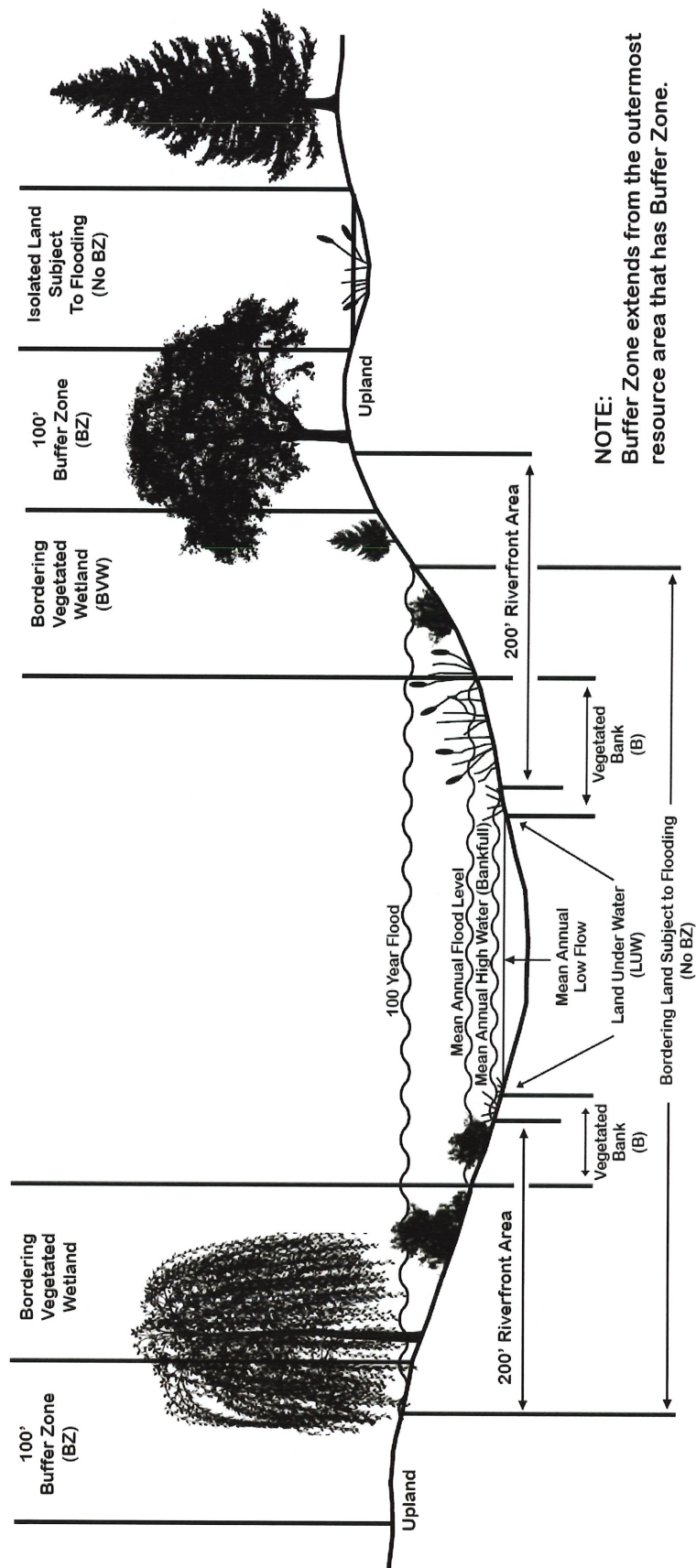
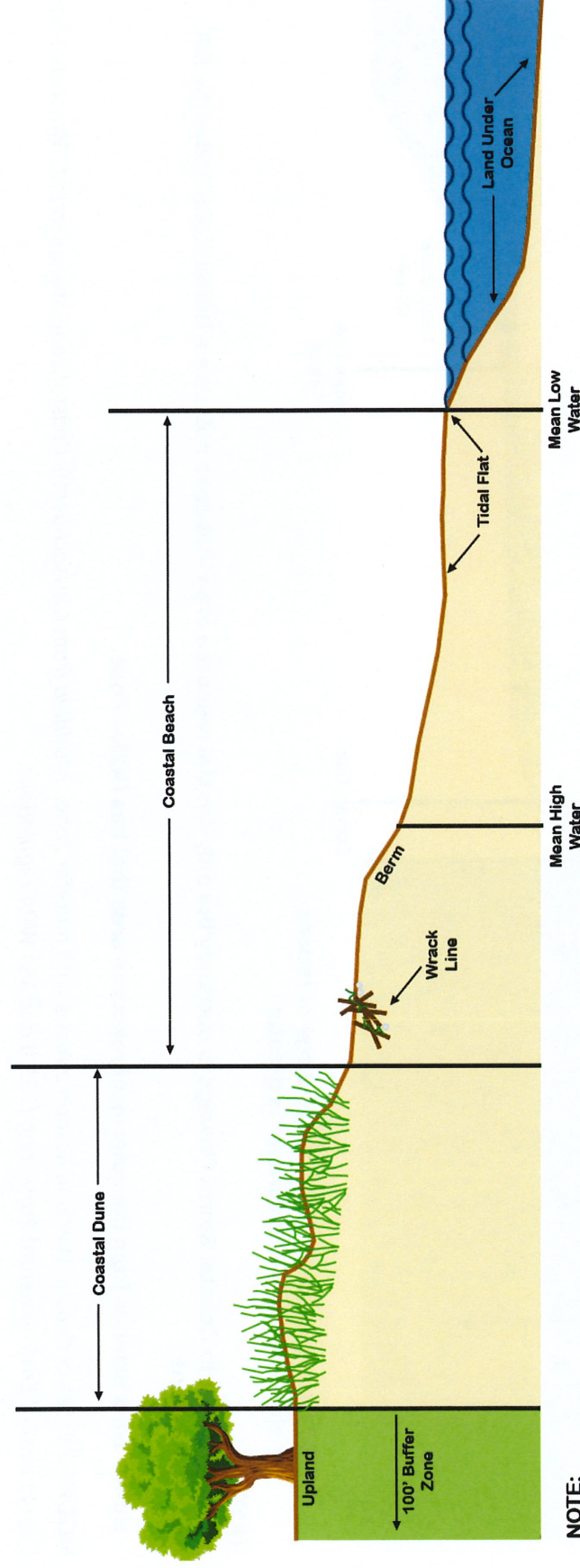
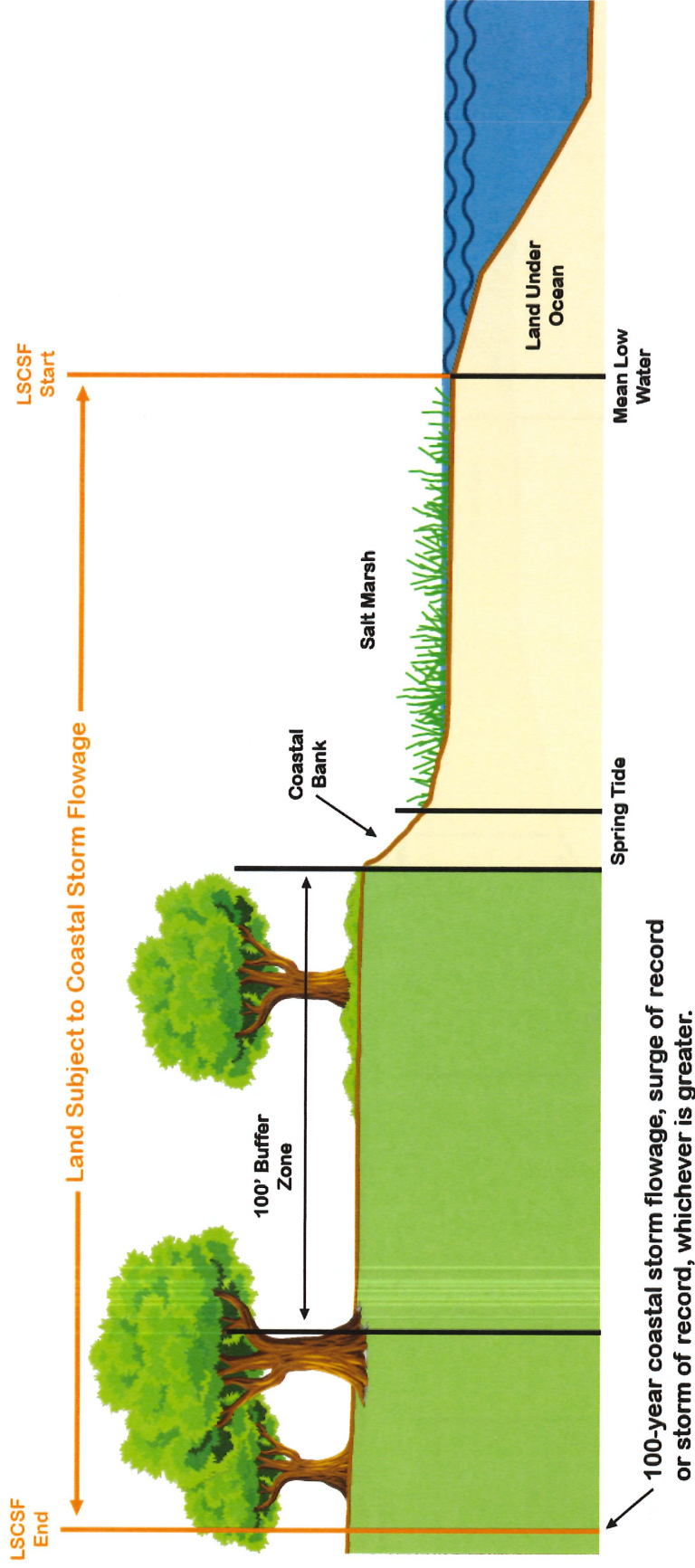


FIGURE 1: Inland Wetland Resource Areas and associated Buffer Zones. Modified from: Massachusetts Department of Environmental Protection (personal communication) and MA WPA regulations.



NOTE:
Buffer Zone extends from the outermost resource area that has Buffer Zone.

FIGURE 2A: Select Coastal Wetland Resource Areas with a Buffer Zone. Modified from Massachusetts Coastal Zone Management, Massachusetts Department of Environmental Protection (2017) and MA WPA regulations.



NOTES:

- Land Subject to Coastal Storm Flowage is currently the only coastal resource area that does not have a Buffer Zone under the MA WPA regulations.
- Buffer Zone extends from the outermost resource area that has Buffer Zone.

FIGURE 2B: Select Coastal Wetland Resource Areas with a Buffer Zone. Modified from Massachusetts Coastal Zone Management, Massachusetts Department of Environmental Protection (2017) and MA WPA regulations.

The WPA and regulations do not provide performance standards for the Buffer Zone. Therefore, there is no measurable method to demonstrate whether a project in the Buffer Zone will or will not affect a Resource Area. However, the General Provisions at 310 CMR 10.03(1) describe the Burden of Proof where:

- a. Any person who files a Notice of Intent to perform any work within an Area Subject to Protection Under M.G.L. c. 131, § 40 or within the Buffer Zone has the burden of demonstrating to the issuing authority...
- b. that proposed work within the buffer zone will contribute to the protection of the interests identified in M.G.L. c. 131, § 40.

Likewise, the Applicant has the burden of proof to demonstrate compliance with Buffer Zone regulatory criteria listed at 310 CMR 10.24(1) and 10.53(1).

1.3.1.1 Exempt Minor Activities

WPA regulation Section 310 CMR 10.02(2)(b) identifies minor activities located in the Buffer Zone that are exempt from regulatory review under the WPA as long as they comply with certain requirements. In order to qualify for exempt status, the listed minor activities must be performed solely in the Buffer Zone (i.e. not in Resource Areas with the exception of Riverfront Area) and must be conducted to, "...reduce the potential for any adverse impacts to the resource area during construction, and with post-construction measures implemented to stabilize any disturbed areas." The conservation commission's defensible decisions should consider the following factors:

- Extent of work;
- Proximity to Resource Area;
- Need for erosion and sediment controls; and
- Measures employed to prevent adverse impacts to Resource Areas during and post construction.

The minor activities that qualify for this exemption are listed in detail in Appendix B.

1.3.1.2 Riverfront Area

Regulations incorporating the "Riverfront Area" provisions of the Rivers Protection Act were adopted in 1997 and effectively made part of the WPA Regulations. Additional regulatory provisions were added in 1998 and again in 2000, with the revision of the definition of "Mean Annual High Water" effective May 12, 2000. Further changes were adopted in 2005.

According to 310 CMR 10.58(2)(a), Riverfront Area means:

"... the area of land between a river's mean annual high water line and a parallel line measured horizontally. The riverfront area may include or overlap other resource areas or their buffer zones. The riverfront area does not have a buffer zone."

Riverfront Areas are unique Resource Areas in that they protect the natural integrity of the waterbody they border, much like a buffer zone. For example, the presence of natural vegetation within Riverfront

Area is critical to sustaining rivers as ecosystems and preventing degradation of water quality by filtering sediments, toxic substances (such as heavy metals), and nutrients (such as phosphorus and nitrogen) from stormwater, nonpoint pollution sources, and the river itself. Forested and shrub/scrub land adjacent to waterways and water bodies provide shading, thereby maintaining cooler water temperatures (see Section 4.2.2.3) and add woody debris to the physical structure and food chain (see Section 2.3.3) of riverine systems. Because of this “buffering function”, this Guidebook considers Riverfront Area in the context of buffer zones. It should be noted that Riverfront Areas, unlike Buffer Zones, are regulated as Resource Areas, and have their own Performance Standards. Additionally, Riverfront Areas are independent of other Resource Areas and the Buffer Zone, meaning that they can overlap areas regulated as Bordering Vegetated Wetland, Buffer Zone, etc. *Overlapping Resource Areas Along a River*, from the 2006 MACC Handbook, (Figure 13, in Appendix E), provides an example of how these different Resource Areas and Buffer Zone might look on a site plan.

Appendix E provides a brief guide to Riverfront Area regulations. A more detailed discussion can be found in *Protecting Wetlands and Open Space: MACC’s Environmental Handbook for Massachusetts Conservation Commissioners* ([MACC Handbook](#)).

1.3.2 Local Wetland Bylaws and Ordinances

Municipalities have the legal authority to enact local wetland bylaws or ordinances in addition to protecting wetlands and Riverfront Areas under the WPA. Local Bylaws and Ordinances may establish more protective standards for Buffer Zones, including protection of the Buffer Zone as a Resource Area. Section 3.2 and Chapters 4.0 and 5.0 provide further information regarding protection of Buffer Zones under local Bylaws and Ordinances.

1.3.3 Key Definitions Based in Science

Turning to scientific literature and non-regulatory definitions, the *Massachusetts Buffer Manual* (Berkshire Regional Planning Commission 2003) defines vegetated buffers (in part) as:

“living filters” that serve as, “...protective area[s] between a waterbody and human activity, such as development or agriculture.”

Jon Kusler and the Association of State Wetland Managers (2009) state that “buffer” means:

“The area surrounding a wetland that helps maintain the wetland’s functional integrity and furnishes protection against the impacts to the wetland from activities in adjacent upland areas.”

and that “Riparian Area” means:

“The area adjacent to rivers, streams, creeks, washes, arroyos, and other bodies of water or channels having banks and bed through which waters flow at least periodically. These areas are subject to periodic flooding and are generally characterized or distinguished by a difference in plant species composition or an increase in the size and/or density of vegetation as compared to upland areas.”

EPA defines Riparian Areas as:

“Vegetated ecosystems along a waterbody through which energy, materials, and water pass.”

The State of Washington Department of Ecology has conducted extensive studies on buffers, including riparian corridors, and defines buffers as follows (Granger et al 2005; Sheldon et al 2005; Hruby 2013):

“Buffers are vegetated areas adjacent to aquatic resources that can, through various physical, chemical, and/or biological processes, reduce impacts to these resources from adjacent land uses. Buffers also provide some of the terrestrial habitats necessary for wetland-dependent species that require both aquatic and terrestrial habitats.”

The varying definitions of buffers and riparian corridors all reference the protective nature of the buffer/riparian corridor, relative to the functioning of adjacent wetlands and/or waters. In ensuing Chapters, this Guidebook elaborates on the mechanisms through which buffers/riparian corridors protect adjacent resource areas.

1.4 Organization

This Guidebook is organized into chapters addressing the following categories of information:

Chapter 1.0 - Purpose & Organization of Guidebook. This chapter provides a discussion of the purpose and organization of the Guidebook and a general regulatory overview of the state Wetlands Protection Act and local bylaws and ordinances, and also provides key definitions used in the Guidebook.

Chapter 2.0 - State of the Science: Buffer Zones. Chapter 2 provides a review of scientific and regulatory literature that Commissions may use to support their findings and decisions pertaining to work in the Buffer Zone. This Chapter explains how buffer zones and riparian corridors contribute to the protection of the adjacent wetland resource areas and associated Interests of the Act (ecosystem services/functions and values), thereby contributing to human well-being.

Chapter 3.0 – Reviewing a Project in the Buffer Zone. This chapter provides information on how conservation commissioners can base findings and decisions on science (outlined in Chapter 2.0) pertaining to the ecosystem services/functions and values of buffer zones and resource areas. This chapter addresses:

- Decision making under the MA Wetlands Protection Act Regulations
- Project review considerations
- Preparation of project specific conditions
- Use of the Findings section of an Order of Conditions as an opportunity to provide the rationale for placing conditions on activities within the Buffer Zone
- Decision making under existing local Bylaws/Ordinances
- Science-based performance standards and findings under Bylaws/Ordinances

Chapter 4.0 – Local Bylaws and Ordinances: Climate Science and Other Considerations. Chapter 4 provides information on opportunities for conservation commissions to protect additional wetland ecosystem services/functions beyond those identified as Interests of the Wetlands Protection Act. Examples include climate-related ecosystem services, recreation, education, aesthetics, and spiritual and economic values.

Chapter 5.0 – Writing Wetland Bylaws and Ordinances: Developing Science and Performance-based standards for Buffer Zones. This chapter provides information concerning how to develop local Bylaws/Ordinances that include science-based performance-based standards for regulating the Buffer Zone, as well as other important components of Bylaws/Ordinances with regard to protecting Buffer Zones and their associated adjacent wetland resource areas.

References. This section provides an extensive list of scientific and regulatory literature that supports the important role that buffer zones play in protecting adjacent wetland resource areas and is intended to be a source for Commissions when they wish to support findings and decisions with citations. A separate list of references is provided that includes literature documenting the economic value of wetlands and buffer zones. References pertain to buffer zones, riparian corridors, wetlands, ecosystem services/functions & values, climate change, and the economic valuation of wetlands and buffer zones.

Appendix A – Additional Definitions, Acronyms and Abbreviations. Appendix A provides information related to terms used in this Guidebook. Definitions, acronyms, and links to additional references are included in this section.

Appendix B – Buffer Zone Project Filing Procedures and Exempt Minor Activities. This Appendix provides excerpts from the Massachusetts Wetlands Protection Act regulations (310 CMR 10.02, 10.24, and 10.53).

Appendix C – Sample Special Conditions. Sample special conditions are included for conservation commissions to use as a guide. Staging area, construction equipment, site cleanup, stormwater management, wildlife, limits of work, erosion controls, and other examples are provided (if applicable) to municipalities when issuing decisions.

Appendix D – Clearwater Estates Case Studies. This appendix contains hypothetical case studies to assist conservation commissions in understanding the process of incorporating science-based buffer zone protections as part of issuing project determinations. These case studies, and series of questions, were developed for Conservation Commission training, and can be used by commissions as a learning tool. Actual projects have site specific considerations that can be very different from the examples in this Appendix.

Appendix E – Summary Guide to Riverfront Area Regulations. Appendix E provides a summary of the Riverfront Area Regulations (310 CMR 10.58).

Appendix F – Model Regulations Under MACC Model Bylaw for Activities in the Buffer Zone. Appendix F provides model regulations that are intended to implement the MACC Model Bylaw with regard to the Buffer Zone.

1.5 How to Use This Guidebook

This Guidebook is intended to be the primary source document for Massachusetts Conservation Commissioners seeking information and guidance when reviewing activities in the 100-foot Buffer Zone to Resource Areas regulated under the Massachusetts Wetlands Protection Act and implementing regulations, and under local bylaws and ordinances.

Using the Table of Contents will allow readers to navigate to broad topics of interest at the chapter level. Every chapter gives a general overview of the topic, as well as specific details related to that chapter. The Guidebook has been prepared as a reference for conservation commissions, but it is not intended to replace the legal authority and interpretation of the Wetlands Protection Act and associated regulations.

The Wetlands Protection Act regulations do not provide performance standards for 100-foot Buffer Zones. As a result, conservation commissions must make decisions in accordance with the role that Buffer Zones play in protecting the interests of the Wetlands Protection Act associated with regulated wetlands and waterways, and in accordance with regulatory criteria at 310 CMR 10.24(1) and 10.53(1).

The science and analyses provided in this Guidebook are intended to assist conservation commissions in their efforts to evaluate Buffer Zone projects on a case-by-case basis in this regulatory context, as well as in the context of local bylaws and ordinances.

1.6 Acknowledgement and Thanks

MACC gives special thanks for this, the first edition of the Buffer Zone Guidebook, to the following individuals and groups:

- **Massachusetts Environmental Trust (MET)**, whose generous grant to MACC made the production of this document possible. MET grant funds come from the proceeds of sales of three environmental license plates from the Registry of Motor Vehicles: The right whale plate; the leaping brook trout plate; and the Blackstone Valley Mill plate. More than 30,000 Massachusetts drivers support this important program. You can help ensure that grant funds for natural resources protection are available by purchasing one of the plates from the Registry of Motor Vehicles. To purchase your environmental specialty plate, visit your local Registry of Motor Vehicles or go to www.massrmv.com and select “Online Services” and then “Order a special plate.” To learn more about the Massachusetts Environmental Trust, please visit: <https://www.mass.gov/orgs/massachusetts-environmental-trust> and <https://www.mass.gov/service-details/types-of-specialty-environmental-license-plates>.
- **BSC Group, and specifically Gillian Davies with assistance from Eric Pasay**, authored this Guidebook. The following BSC staff also assisted Gillian in preparation and/or review of the Guidebook: Lee Curtis, Ingeborg Hegemann, George Andrews, and Kait Rimol.
- **MACC’s Buffer Zone Editorial Team:** Jennifer Carlino, Pamela Harvey, Michael Howard, Michele Girard, Matt Schweisberg, and Janice Stone, with support from Sandra Brock, Rebekah Lacey and other MACC Directors.
- **Other individuals and organizations:** Many thanks to the other individuals who reviewed, commented, and participated in making this edition of the Guidebook a reality including: Nancy Lin and other staff at the Massachusetts Department of Environmental Protection; MACC staff: Lindsay Martucci, Michele Girard and Dot McGlinchy.

1.7 Massachusetts Environmental Trust

The Buffer Zone Guidebook was supported by a grant from Massachusetts Environmental Trust. It is our hope that conservation commissioners and other professionals will find this to be a helpful resource as they work to protect our beautiful Commonwealth.

Supporting conservation commissions has been a longstanding area of interest for MET. In addition to this Guidebook, MET has provided grants to MACC for web-based training programs and expanded training programs in new locations around the state.

MET supports municipalities and nonprofit organizations statewide as they work to protect and restore our water resources. MET makes grants for water quality, water quantity, education, conservation of endangered species, and the continuity of aquatic habitats.

Funding for MET grants comes from the proceeds of sales of three environmental license plates from the Registry of Motor Vehicles: The right whale plate, the leaping brook trout plate, and the Blackstone Valley Mill plate. Over 30,000 drivers in the state support this important program.



You can help ensure that grants continue to be available simply by purchasing one of these license plates from the Registry of Motor Vehicles.

To purchase your environmental specialty plate, visit your local Registry of Motor Vehicles or log on to www.massrmv.com and select “Online Services” then “[Order a special plate](#)”

The initial registration fee for a new plate is \$60; the special plate fee is \$40.

The total first-time cost of an Environmental Specialty Plate is \$100. The renewal fee (every 2 years) is \$100.

To learn more about the Massachusetts Environmental Trust, please visit www.mass.gov/eea/met

2.0 STATE OF THE SCIENCE: BUFFER ZONES

2.1 Need for Science-Based Decision Making

Conservation commissions should make decisions that are based in science in order to implement the WPA consistently, and with credibility and equity. Science-based decision-making is important in the context of both the state WPA and local Bylaws and Ordinances. In addition to regulating under the WPA, municipalities are empowered to enact Wetland Bylaws and Ordinances (as outlined in Section 3.2 and Chapters 4.0 and 5.0), and many have implemented regulations that regulate, restrict and/or prohibit activities and impacts to Buffer Zones in a manner that is more stringent when compared to state level protections.

To be functionally effective, and to withstand scrutiny on appeal, conservation commissions should base their decisions and the development of their local Bylaws/Ordinances and regulations on accepted science regarding the functions and values of buffer zones and resource areas (Environmental Law Institute 2008). In addition to contributing to the functional capacity of wetlands, basing decisions in accepted science supports public education on the importance of protecting wetlands, waterways, water bodies and their buffer zones; reinforces public opinion that decisions are not arbitrary; and enlists public support when Commissions seek to develop Wetlands Bylaws and Ordinances.

Sections of this Guidebook discuss and summarize research literature and other science-based documents that provide the rationale and justification for making scientifically sound, defensible decisions at both the state and local levels and, at the local level, for establishing specific Buffer Zone review standards; including prescribed setbacks and limits of work from wetlands, waterways, and water bodies, as well as provide a brief discussion of the scientific rationale for protecting Riverfront Areas, to better achieve functional protection (i.e. protection of the Interests of the Act as well as other ecosystem services).



Source: MACC Fundamentals for Conservation Commissioners Training Program - Unit 104

2.2 Current Science in Support of Buffer Zones

Human alterations to wetlands and adjacent land areas have resulted in impacts to hydrologic connectivity, water quality and quantity, flood storage capacity and storm damage resilience, species habitat and biodiversity, capacity of wetlands to sequester and store carbon, and have reduced ecological and community resilience to climate change (Brinson and Malvárez 2002; Millennium Ecosystem Assessment 2005; Mitsch and Hernandez 2013; Nahlik and Fennessy 2016; Ramsar Convention on Wetlands 2018). The recently published Global Wetland Outlook (Ramsar Convention on Wetlands 2018) provides an assessment of the status and trends of global wetlands, the pressures they face, and their capacity to provide ecosystem services to humans.

Between the 1780s and the 1980s, approximately 53% of wetlands in the conterminous United States were lost, with the rate of loss slowing in the 1970s and 80s as wetland protection measures were implemented (Mitsch and Hernandez 2013).

From 1998 to 2004, wetland losses shifted to 0.44% wetland gains (although U.S. Fish and Wildlife Service inventory system counts open water stormwater and similar ponds), suggesting that wetland restoration and creation may be offsetting losses to some degree (Mitsch and Hernandez 2013).

Estimates are that by the mid-1980's Massachusetts had lost approximately 28% of the area believed to have originally been wetlands, with an additional loss of 0.2% from the mid-1990's to 2011 (EEA and AAC 2011). Other data indicate that loss of natural wetlands continues at a global scale and across the majority of wetland classes, whereas wetlands (such as rice paddies and water storage bodies) constructed by humans are increasing in area (Davidson & Finlayson 2018; Davidson & Finlayson 2019; Ramsar Convention on Wetlands 2018). Davidson, et al. (2018) documents that the global trend for loss and conversion of natural wetlands continues. Additionally, concerns remain that wetland ecological function is not always restored when wetland replication/creation is provided as a form of mitigation (Mitsch and Hernandez 2013). Researchers note the need to more fully assess the extent of both natural and human-constructed wetlands, as data has not been available for all areas of the world (Davidson et al 2018).

In terms of understanding the financial cost to society for land use change, Costanza et al (2014) find that a conservative estimate of the economic value of ecosystem services lost due to global land use changes between 1997 and 2011 is between \$4.3 and \$20.2 trillion per year. Wetland and buffer zone/riparian corridor land use change contribute to these totals.

Regarding the impact of land use change on anthropogenic climate change, researchers estimate that close to one third of the carbon dioxide added to the atmosphere from human activity between 1750 and 2011 is the result of land use change (i.e. deforestation and disturbance of soil organic matter) (Ciais et al 2013). Loss and disturbance of wetlands contributes to carbon emission totals, as wetlands contain 20% - 30% of the world's soil carbon, despite occupying only 5% - 8% of the global land surface (Nahlik and Fennessy 2016).

2.3 Summary of Buffer Zone Literature Review

This Chapter of the Guidebook provides summaries of scientific literature that address the roles of buffers, including riparian corridors, in protecting and contributing to the ecosystem services/functions provided by Resource Areas¹. The wetland ecosystem services/functions associated with the eight protected Interests of the Act are organized in three representative groupings as follows:

- 1) Protection of Public and Private Water Supplies, Groundwater Supply, and Pollution Prevention;
- 2) Flood Control and Storm Damage Prevention; and
- 3) Wildlife and Fisheries Habitat and Land Containing Shellfish.

Note that Chapter 4.0 of this Guidebook includes a discussion of additional ecosystem services/functions that are not identified explicitly or directly regulated in the WPA and implementing regulations (310 CMR 10.00). These include ecosystem services associated with climate change and sea level rise, recreational interests and other similar topics, as well as discussion of the economic value of wetland resources. The

¹ In Massachusetts, wetlands and related ecological features such as banks, waterways and water bodies are regulated as "Resource Areas" or the Areas Subject to Protection under M.G.L. c. 131, § 40, each one of which is enumerated in 310 CMR 10.02(1). Resource Areas are defined in the regulations implementing the Wetlands Protection Act (specifically 310 CMR 10.25 through 10.35 and 10.54 through 10.58).

role of buffers in providing protection to wildlife from artificial light and noise, and protection from direct human disturbance is included in Section 4.4.

It is interesting to note that all the Interests of the Act include functions that relate to provision of climate adaptation and resiliency ecosystem services, even though the enactment of the WPA and identification of the Interests predates our current understanding of the role of wetlands in provision of climate adaptation and resiliency ecosystem services. Therefore, even though the existing WPA and associated regulations do not include language specific to climate change, they nevertheless contribute to protection of ecosystem services that provide climate adaptation and resiliency functions to both human communities and to ecosystems and contribute to the protection of soil and biomass carbon in Resource Areas and Buffer Zones. For this reason, review of the more detailed discussion of the relationship between wetlands and our changing climate, provided in Chapter 4.0, is recommended.

The following subsections provide information from the scientific literature on buffer zone science, including recommended buffer zone widths. A particularly extensive recent review of buffer zone science, including width studies, *Update on Wetland Buffers: The State of the Science*, was published by the State of Washington Department of Ecology in 2013. Other recent reviews and reports include the New Hampshire Association of Natural Resource Scientists Wetland Buffer Scientific Working Group's *NHANRS Scientific Wetland Buffer Report* (NHANRS Legislative Committee 2017), *A Review of Vegetated Buffers and a Meta-analysis of Their Mitigation Efficacy in Reducing Nonpoint Source Pollution* (2010) by Zhang et al., the Environmental Law Institute's (ELI) *Planner's Guide to Wetland Buffers for Local Governments* (McElfish, JM Jr et al 2008), and the Massachusetts Department of Environmental Protection's *The Massachusetts Buffer Manual* (Berkshire Regional Planning Commission 2003). Discussion of buffer widths from the Washington Department of Ecology (Hruby 2013), Zhang et al (2010) and ELI (McElfish, JM Jr et al 2008) reports are summarized in following subsections, as they are viewed as being the most recent and comprehensive.

2.3.1 PROTECTED INTERESTS: Protection of Public and Private Water Supplies, Groundwater Supply and Pollution Prevention

2.3.1.1 Science Supportive of WPA Ecosystem Interests

Upland buffer zones, including riparian corridors, protect the ecosystem services/functions and values of wetlands, waterways and water bodies by maintaining water quality, hydroperiods and water budgets. Buffers and riparian areas contribute to the ability of adjacent wetlands and waters to absorb flood waters and to maintain base flows during dry times. These functions help to maintain both the water quality and water quantity that maintain our public and private water supplies and protect our groundwater supplies. Massachusetts is experiencing increased incidence of heavy precipitation events and increased incidence of drought because of climate change, as noted on the [Massachusetts Executive Office of Energy and Environmental Affairs](#) (EEA) website. This increases the need for the flood storage capacity and water provisioning ecosystem services provided by wetlands and supported by adjacent buffers and riparian corridors. Given the projected increases in floods and droughts, municipalities may wish to develop performance standards through local Bylaws/Ordinances that protect the contribution that Buffer Zones make to the protection of public and private water supply and protection of groundwater supply Interests of the Act. Section 3.2 and Chapter 4.0 provide additional relevant information.

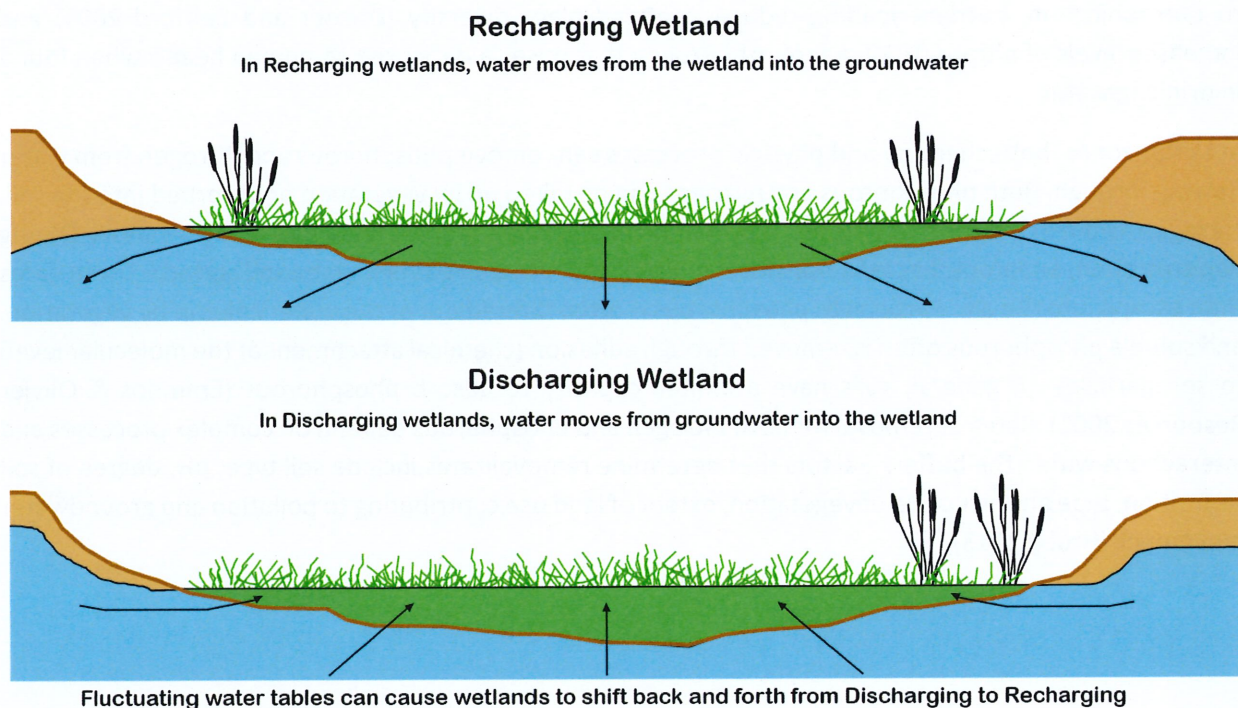


FIGURE 3: Groundwater recharge and discharge. Modified from [Northeastern Area State and Private Forestry](#)

Vegetated buffers, sometimes referred to as “buffer strips,” act as natural filters that absorb and trap nutrients, toxic pollutants, bacteria, sediment, organic material, and debris before it enters a resource area. Vegetated buffer strips work by slowing the velocity of surface water flow, which has the effect of allowing sediments to drop out of the flowing water, increasing recharge to groundwater, and increasing the ability to filter pollutants from flowing water. Contaminants are removed from water through a variety of mechanisms. These include uptake by vegetation, biological conversion to less harmful forms, adherence to soil particles, storage, and chemical reactions within the soil (Correll 1997; Emmons & Olivier Resources 2001; Environmental Law Institute 2008; Hruby 2013; NHANRS Legislative Committee 2017).

Buffer zones, including riparian corridors, are widely studied for their ability to remove nitrogen, phosphorous, sediment, coliform bacteria, and other pollutants associated with agriculture and land development (Lee et al 2003; Hruby 2013; NHANRS Legislative Committee 2017). Heavy use of fertilizers and drainage from nutrient rich manure and wastewater creates inputs of nitrogen and phosphorous pollution. Erosion and transport of exposed soils from agricultural fields, construction sites, and unstable banks flushes sediment and other contaminants into wetlands and waterways during rainstorms, highlighting the importance of vegetated buffers between wetland resource areas and agriculture, construction, and development.

Inputs of nitrogen and phosphorous pollution, called nutrient loading, cause eutrophication which can lead to algal blooms in water. Eutrophication is the process by which excess nutrients promote the rapid growth of plant life that ultimately reduces oxygen levels in water and suffocates aquatic life. In many cases, eutrophication causes the rapid growth of cyanobacteria, or blue-green algae, which produce cyanotoxins that are harmful to humans and animals. Cyanotoxins can be particularly problematic when contaminated water is used for drinking, bathing or irrigation. Climate change is expected to increase the frequency, scale and toxicity of cyanobacteria blooms (O'Neil et al 2012; Paerl and Paul 2012). In addition to eutrophication, nutrient loading reduces wetland plant diversity (Drexler and Bedford 2009) and increases levels of nitrate (NO_3), a form of nitrogen that poses a direct risk to human health when found in drinking water.

In buffer zones, both chemical and physical processes can remove phosphorous and nitrogen from water flowing through. Both phosphorous and nitrogen can be taken up by vegetation or absorbed into the soil. Nitrogen, often in the form of nitrates, is primarily removed in a process known as denitrification. During denitrification, anaerobic bacteria transform nitrates into nitrogen gas below the soil surface. These gases then escape into the air. Particulate phosphorous is often filtered out of the water column by vegetation, and soluble phosphorous often is removed through adhesion (chemical attachment at the molecular level) to soil particles. In general, soils have a limited capacity to adsorb phosphorous (Emmons & Olivier Resources 2001). Rates of removal for both nitrogen and phosphorous depend on complex processes and interactions within the buffer. Factors that determine removal rates include soil type, pH, degree of soil saturation, type and structure of vegetation, extent of land use contributing to pollution and groundwater movement (Hruby 2013).



Source: MACC Fundamentals for Conservation Commissioners Training Program - Unit 104

Sediment pollution can be suspended in the water column or deposited on the substrate of wetlands or streams. When suspended in the water column, sediment pollution causes extensive changes to aquatic ecosystems (Newcombe and Macdonald 1991). Some of these changes include increased turbidity, changes to water temperature and chemistry, increased stress on aquatic biota and damages to costly infrastructure such as culverts and water filtration systems. When deposited in a wetland or streambed, sediment reduces storage capacity, alters soil chemistry and stresses fish and macroinvertebrates in a variety of ways (Wood & Armitage, 1997). In addition, sediments can transport toxic chemicals into wetlands and waters.

Within buffers, sediment is removed through settling and deposition, as overland flow is slowed by friction, and infiltrates into the soil (Gharabaghi et al 2006). In general, coarser sediments are more effectively filtered than fine sediments because they are heavier and more easily deposited (Barling and Moore 1994). Sediment removal is highly dependent on site-specific factors such as vegetation structure and density, soil saturation and surface runoff contact with buffer area (Hruby 2013). One study of four buffer zones found that only 9-18% of the total buffer area made contact with surface runoff, resulting in a 15-43% trapping efficiency of sediment (Dosskey et al 2002).

In addition to sediment and nutrient removal, buffers filter biological pathogens that accumulate in drinking water and shellfish used for human consumption. Biological pathogens include bacteria that cause disease and illness in humans. Fecal coliform describes a group of common biological pathogens,

such as *E. coli*, that are discharged into waterways from farms, wastewater and wildlife or domesticated animal excrement. In most cases, buffers have been shown to reduce significant amounts of fecal coliform concentrations produced by agricultural runoff (Lim et al 1998; Sullivan et al 2007).

The effectiveness of buffers in removing pollutants is dependent on slope, soil conditions, pollutant type, location, flow pattern, vegetation, exposure to sunlight, width, and upland land use (Correll 1997; Lee et al 2003; Hawes and Smith 2005; Hruby 2013). Steep slopes increase the velocity at which water travels through a buffer, thereby decreasing the amount of time that water can filter through soil and vegetation. For removal of most pollutants, flat slopes with gradients of less than 5% are desirable (Hruby 2013). For sediment removal, slopes between 8.14 and 11.72% are optimal (Zhang et al 2010) (See Figure 4). Compacted, low permeability soils, such as clay, and compacted glacial till are poor filters because they have low infiltration rates. Conversely, water quickly passes through permeable soils like sand, reducing the amount of time that nutrients can be taken up by vegetation (Hawes and Smith 2005; Adamus 2007). Coarse textured soils tend to have low organic content, and thus do not retain pollutants as well as soils with higher organic content. Moderately coarse soils, such as glacial outwash, are preferable (Adamus 2007).

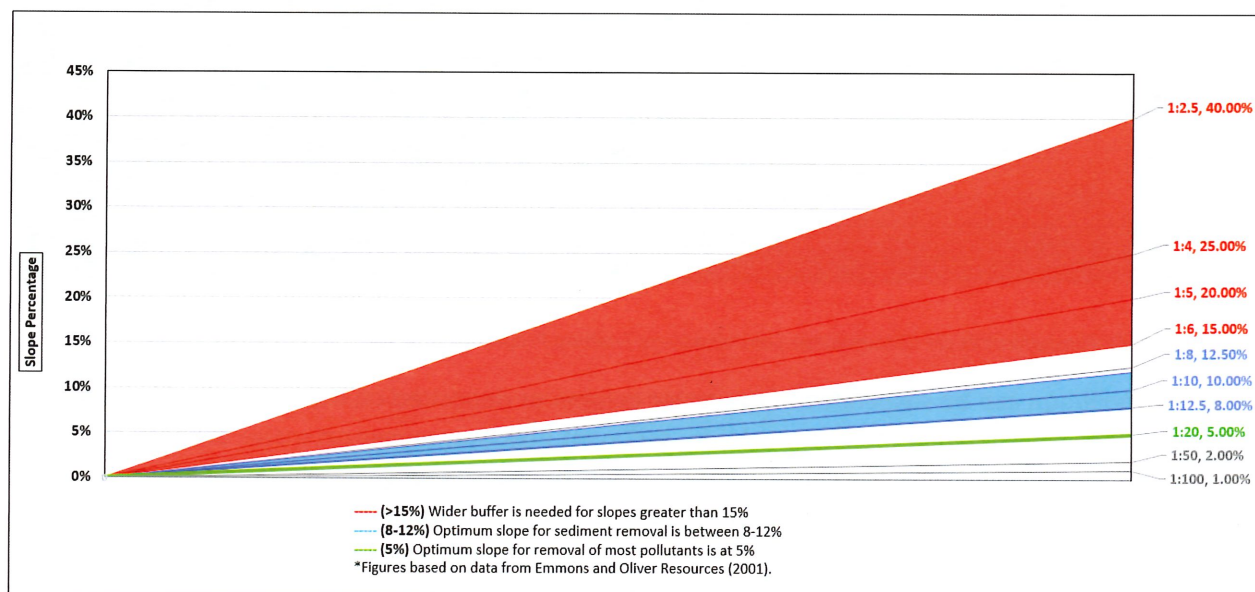


FIGURE 4: Effect of slope on pollutant and sediment removal. Source: Figure is based on data from Emmons and Oliver Resources (2001)

As mentioned, the ability of buffer zones to contribute to maintenance of wetland functions varies based on several factors. Some are discussed below.

Location within the landscape influences buffer zone effectiveness. Some research suggests that buffers are most effective at removing pollutants when they are located adjacent to pollutant sources, rather than surrounding a wetland resource area (Norris 1993). Also, location can affect flow patterns. Buffer zones that promote sheet flow, i.e. uniform flow that is evenly distributed in depth and area, are more effective than channelized buffers (Correll 1997). This is because channelization allows water to bypass vegetation and soil more rapidly, both of which capture water and filter pollutants. Depth of overland flow also plays a role in buffer effectiveness. Shallow overland flows that do not fully submerge vegetation

provide the greatest exposure to plants and soils, thus enhancing filtration capacity. (Barling and Moore 1994).

Vegetation removes pollution through root uptake and friction (also called “roughness”). Vegetation slows runoff velocity so that it has greater potential to infiltrate into the soil and has less erosion potential. Most studies find that buffers dominated by trees or a mix of vegetation cover types (e.g. trees, shrubs and grasses) are most effective in removing nutrients and sediment pollution (Emmons & Olivier Resources 2001; Hawes and Smith 2005; Zhang et al 2010). Removal rates vary depending on the type of pollutant being removed, as well as the distribution and density of vegetation in the buffer. Vegetation that promotes slow, uniform sheet flow is desirable. The effectiveness of different vegetation types for removing pollutants is presented in Table 1. Age of vegetation also influences removal rates. Younger stands of vegetation tend to grow quickly and absorb more nutrients than older stands (Mander et al 1997). In addition to removing pollutants, vegetation improves water quality by stabilizing banks and moderating water temperature through shading (Castelle et al 1994).

		Predicted removal efficacy, %			
	Buffer width =	5 m	10 m	20 m	30 m
Sediment	(a) Slope = 5%; mixed grass and trees	67	76	78	78
	(b) Slope = 5%; grass/trees only	82	91	93	93
	(c) Slope = 10%; mixed grass and trees	77	86	88	88
	(d) Slope = 10%; grass/trees only	92	100†	100	100
	(e) Slope = 15%; mixed grass and trees	58	67	68	68
	(f) Slope = 15%; grass/trees only	73	81	83	83
Nitrogen	(a) Mixed grass and trees/grass only	49	71	91	98
	(b) Trees only	63	85	100	100
Phosphorus	(a) Mixed grass and trees/grass only	51	69	97	100
	(b) Trees only	80	98	100	100
Pesticide		62	83	92	93

† If predicted values exceed 100, the value of 100 was assigned instead.

TABLE 1: Predicted pollutant removal efficacy. Republished with permission of American Society of Agronomy, Inc., from: A review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing nonpoint source pollution. Zhang, X et al. *Journal of Environmental Quality* 39:76-84. 2010. doi: 10.2134/jeq2008.0496. Permission conveyed through Copyright Clearance Center, Inc.

Width is considered one of the most important variables for buffer zones and water quality. This is especially true in areas with intense adjacent land use (Castelle et al 1994; Hickey and Doran 2004). Wider buffers have been shown to reduce nitrogen (Mander et al 1997; Mayer et al 2007), phosphorous (Mander et al 1997; Abu-Zreig et al 2003) and sediment (Dillaha et al 1989; Gharabaghi et al 2006), though width has less of an effect on sediment removal after fifty feet according to Abu-Zreig et al (2004). Zhang et al (2010) found that buffer width is significant in removal of sediments, nitrogen, phosphorous and pesticides, up to a point, beyond which removal rates do not increase significantly. Increasing buffer width appears to be a common practice to offset steep slopes, when slopes exceed 15% (Emmons & Olivier Resources 2001) (See Figure 4 and Table 2). The importance of other buffer variables (such as slope, cover type, soil type, etc.) suggests that width should not be the single factor when establishing a

regulated Buffer Zone or evaluating its effectiveness (Mayer et al 2007; Hruby 2013). Figures 2 and 3 provide buffer width recommendations, based on scientific literature.

SLOPE ADJUSTMENT	
Slope Gradient	Additional Buffer Multiplier
5-14%	1.3
15-40%	1.4
>40%	1.5

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TABLE 2: Water quality value, adjusted for slope. Modified from: McElfish, JM Jr, Kihlsinger RL, Nichols, SS (2008) *Planner's Guide to Wetland Buffers for Local Governments*. Environmental Law Institute.

In addition to protecting the quality of surface and groundwater, buffer zones help control the rate at which water enters and leaves a wetland. Water absorbed within a buffer zone slowly discharges to a wetland as groundwater, thus storing water for a longer period. Water storage is important for maintaining stable drinking water supplies. A report in 1984 concluded that 40% to 50% of wetlands in Massachusetts were potential sources of drinking water and at least sixty municipalities had public wells in or near wetlands (Tiner 1984). Further, with the increasing incidence of drought, storage of water in wetlands and buffer zones becomes even more significant (see Chapter 4.0).

Conversely, wetlands may overflow and saturate buffer zones during flood events, such that buffers effectively become backup flood storage areas, which contributes to protection of water quality by preventing flood waters from picking up toxins in developed areas. The increasing incidence of heavy precipitation, flooding and severe storm events demonstrates the increasing importance of natural infrastructure (wetland resource areas and buffers) in providing climate resiliency for both ecosystems and human communities (see Chapter 4.0). Additionally, provision of water storage capacity has important implications for aquatic organisms that rely on seasonal cues and water level fluctuations for reproduction (Brock et al 2003).

2.3.1.2 Literature Review: Recommended Buffer Zone Widths

Recommended widths of buffer zones (See Figures 5 and 6) that contribute to the protection of the Interests of the Act vary based on site specific conditions and desired goals. In *Washington Department of Ecology: Update on Wetland Buffers: The State of the Science* (Hruby 2013), research consistently documents that,

“...it takes a proportionally larger buffer to remove significantly more pollutants because coarse sediments and the pollutants associated with them drop out in the initial (outer) portions of a buffer. It takes a longer time for settling, filtering, and contact with biologically active root zones to remove fine particles and dissolved nutrients.”

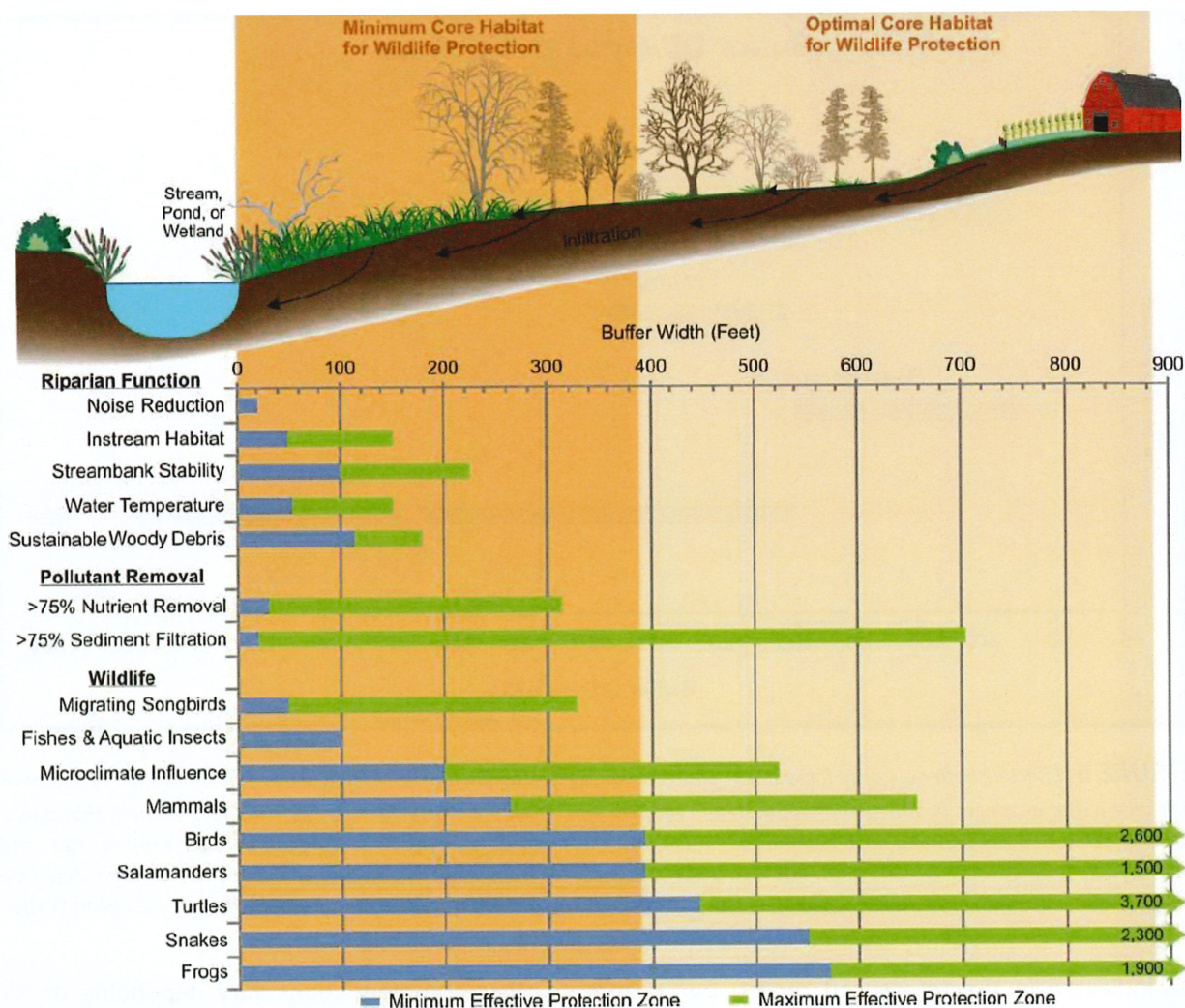


FIGURE 5: Recommended widths of buffers to protect aquatic resources. Reproduced from: Hruby, T. (WDOE). (2013). Update on wetland buffers: The state of the science.

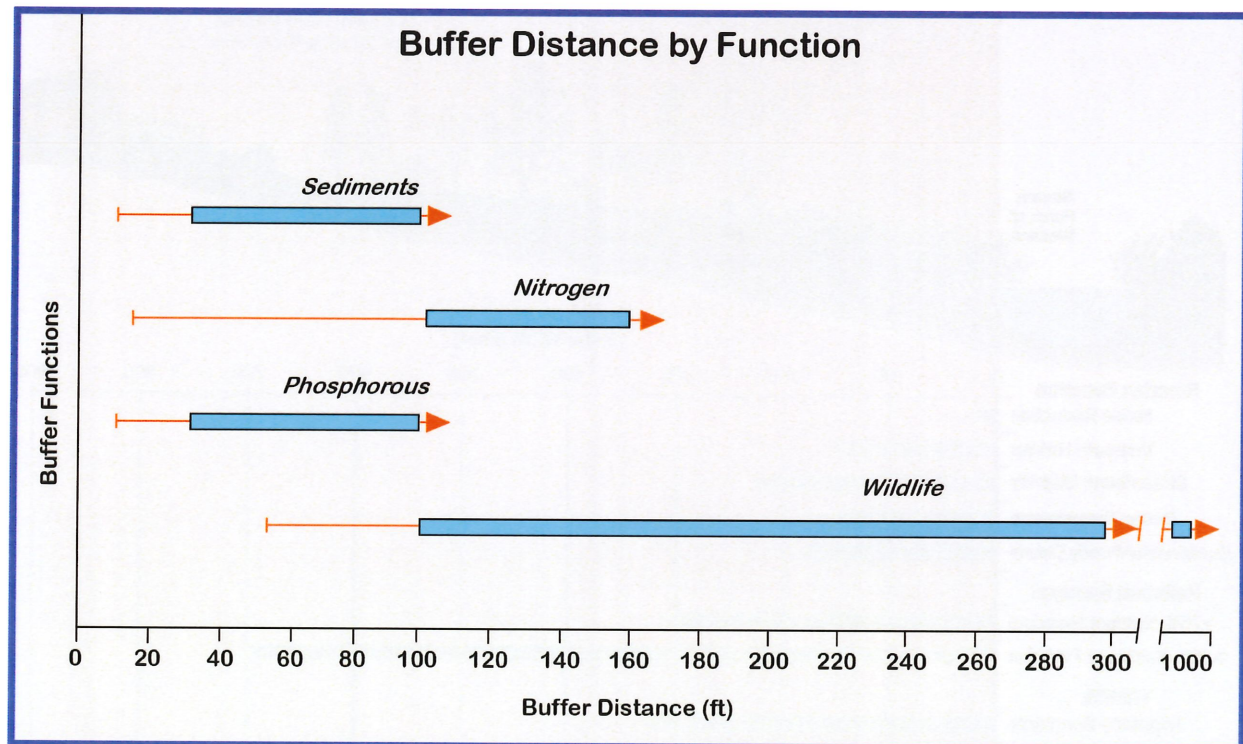


FIGURE 6: Effective buffer distance for water quality and wildlife protection functions. Thin arrow indicates range of potentially effective buffer distances by function as suggested in the scientific literature. Thick bar represents buffer distances that may be **most** effective in accomplishing each function (sediment and phosphorous removal 30 - >100 feet; nitrogen removal 100 - >160 feet; wildlife protection 100 - >300 feet). Effective buffer distances for wildlife protection may be either small or large, depending on species and habitat characteristics. Modified from McElfish, JM Jr, Kihlslinger RL, Nichols, SS (2008) *Planner's Guide to Wetland Buffers for Local Governments*. Environmental Law Institute.

As indicated in the referenced report, buffer zone width recommendations vary depending on the targeted pollutant removal:

- >75% Sediment Filtration: 20 feet minimum width, 700 feet optimal width;
- 75% Nutrient Removal: 30 feet minimum width, 310 feet optimal width;
- Maintenance of Water Temperature: 50 feet minimum width, 150 feet optimal width; and
- Microclimate Influence: 200 feet minimum width; 520 feet optimal width.

This Washington Department of Ecology study concludes that width alone is not sufficient to determine the effectiveness of a buffer in protecting the adjacent wetland, but that in general, wider buffers are more effective than narrow buffers. See Chapter 3.0 for a detailed outline of additional factors to consider, including the condition, landscape position, and geomorphology of the buffer zone and the adjacent wetland resource area.

The Environmental Law Institute's *Planner's Guide to Wetland Buffers for Local Governments* (ELI Planner's Guide) (2008) notes (in part) that:

Depending on site conditions, much of the sediment and nutrient removal may occur within the first 15 – 30 feet of the buffer, but buffers of 30 – 100 feet or more will remove pollutants more consistently. Buffer

distances should be greater in areas of steep slope and high intensity of land use. Larger buffers will be more effective over the long run because buffers can become saturated with sediments and nutrients, gradually reducing their effectiveness, and because it is much harder to maintain the long-term integrity of small buffers ... Buffers of less than 50 feet were more susceptible to degradation by human disturbance. In fact, no buffers of 25 feet or less were functioning to reduce disturbance to the adjacent wetland.

According to the [ELI Planner's Guide](#) minimum and most effective buffer widths for removal of sediment nitrogen and phosphorous are as follows:

- Sediments: < 20 feet minimum, and 30 to 100+ feet for most effective results;
- Phosphorous: < 20 feet minimum, and 30 to 100+ feet for most effective results; and
- Nitrogen: < 20 feet minimum, and 100 to 180+ feet for most effective results.

Island County, Washington (*ELI Planner's Guide Appendix II* (McElfish, JM Jr et al 2008)) developed a matrix approach to determining appropriate buffer widths. The matrix adjusts buffer widths depending on site specific factors including land use intensity, quality of wildlife habitat in the buffer zone, wetland type, and provides multipliers to adjust buffer widths according to slope gradient.

Zhang et al's A Review of Vegetated Buffers and a Meta-analysis of Their Mitigation Efficacy in Reducing Nonpoint Source Pollution (2010) finds that:

Buffers composed of trees have higher N and P removal efficacy than buffers composed of grasses or mixtures of grasses and trees. Soil drainage type did not show a significant effect on pollutant removal efficacy. Based on our analysis, a 30-meter buffer under favorable slope conditions (= 10%) removes more than 85% of all the studied pollutants.

2.3.1.3 Key Points

The key points from the literature sources described above can be summarized as follows:

- Buffer zones help control the rate at which water enters and leaves a wetland, maintain base flows during dry times, and store excess water during floods.
- The water storage/water supply and water quality functions of wetland resource areas and their buffers are becoming more important as they provide climate resiliency ecosystem services that enhance the capacity for communities and ecosystems to maintain clean and plentiful water during droughts, while simultaneously minimizing water quality impacts from floods and severe storm events. See Chapter 4.0.
- Vegetated buffers, sometimes referred to as "buffer strips," act as natural filters that absorb and trap nutrients such as nitrogen and phosphorous, toxic pollutants, biological pathogens such as coliform bacteria (*E.coli* and fecal coliform), sediment, organic material, and debris before it enters a wetland resource area.
- Most studies find that buffers dominated by trees or a mix of vegetative cover types (e.g. trees, shrubs and grasses), structure and age classes are most effective in removing nutrients and sediment pollution.

- Width alone is not sufficient to determine the effectiveness of a buffer in protecting the adjacent wetland, but in general, wider buffers are more effective than narrow buffers. Steep slopes accelerate speed of water flowing through the buffer, thus reducing filtering time. Increasing the buffer width can, to some extent, offset steep slopes in the buffer.
- Vegetated buffers between 30 and 100+ feet appear to be effective in reducing sediments, phosphorus and nitrogen, with 75% removal rate; and
 - Phosphorus and sediment removal capacity is most effective within 50 feet of the resource area.
 - Nitrogen removal capacity is most effective within at least 100 feet of the resource area.
 - Vegetated buffer width of minimum 50 feet is most effective to maintenance of water temperature.
 - Buffers of less than 50 feet were more susceptible to degradation by human disturbance. In fact, no buffers of 25 feet or less were found to be functioning in a meaningful way to reduce disturbance to the adjacent wetland.
- The effectiveness of buffers in removing pollutants is dependent on slope, soil conditions, pollutant type, location, flow pattern, vegetation, exposure to sunlight, width and proposed and existing upland land use. Buffer zones that promote sheet flow, i.e. uniform flow that is evenly distributed in depth and area, are more effective than channelized buffers. See Figure 4.
 - For removal of most pollutants, flat slopes with gradients of less than 5% are desirable (Hruby 2013).
 - For sediment removal, slopes between 8.14 and 11.72% are optimal (Zhang et al 2010).
 - Increasing buffer width is common when slopes are steeper than 15% (Emmons and Olivier Resources 2001).

Additionally, the water storage/water supply and water quality ecosystem services provided by wetland resource areas and buffer zones have significant economic and social value. Conservation commissions may wish to provide education to their communities, which may lead to greater support for state and local wetland protection laws and regulations and increased wetland conservation. See Chapter 4.0, particularly Section 4.6. Further, municipalities may wish to consult available resources for assessing present and future risks to water supplies and water quality as our climate changes and may wish to evaluate how these increasing risks intersect with existing natural infrastructure in their communities, such as wetland resource areas and their buffers. Conservation commissions may wish to work with others in the community to identify opportunities to enhance, create and restore natural infrastructure that provides protection of water supplies and water quality.

2.3.2 PROTECTED INTERESTS: Flood Control & Storm Damage Prevention

2.3.2.1 Science Supportive of WPA Ecosystem Interests

Wetlands help limit damage from flooding by absorbing water during flooding events and extreme weather (Environmental Law Institute 2008), and therefore are often referred to as landscape “sponges” that soak up stormwater and energy. This process, called flood attenuation, helps prevent storm damage to critical infrastructure, drinking water and property. The ability of wetlands to prevent storm damage is impressive. During Hurricane Sandy, coastal wetlands prevented \$625 million in direct flood damage in the Northeastern United States (Narayan et al 2017). Buffer zones help protect the capacity of wetlands to absorb flood waters by protecting the functional integrity of the adjacent wetland and also by providing additional flood storage capacity, should the capacity of the wetland be exceeded.

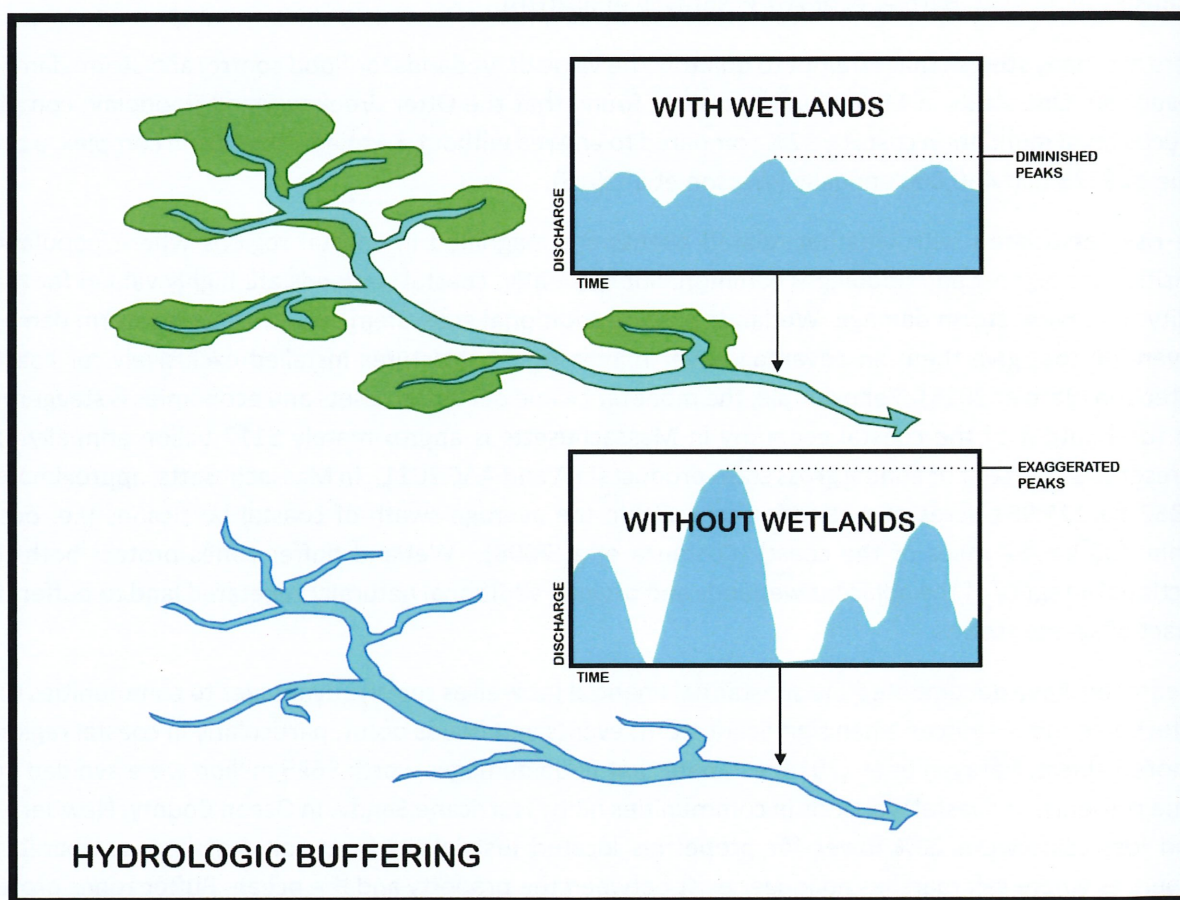


FIGURE 7: Hydrologic buffering. Modified from: Massachusetts Department of Environmental Protection (personal communication).

Wetlands, and the buffer zones that support wetland functioning, prevent storm damage in a variety of ways. For example, inland and coastal wetlands store water during heavy precipitation events and gradually release it as groundwater and surface water after peak flood flows have passed, thus reducing peak flow maximums and flow velocities, and thereby reducing flood damage downstream, as well as in the local vicinity of the wetland. Wetlands provide flood protection near water bodies, such as lakes and ponds, as well as near streams and rivers. In addition, wetlands slow the velocity of overland runoff, thereby slowing sheet flow contributions to peak flows in streams and rivers. Further, buffers remove

sediment from stormwater before it enters a wetland (Gharabaghi et al 2006), which prevents sediment from filling the adjacent wetland and maintains the flood storage capacity of the adjacent wetland. Buffer zones also provide space for additional flood storage during severe storms. Buffer zone vegetation, particularly shrubs and trees, buffers the vegetation in the adjacent wetland resource area, thus reducing storm damages to wetland resource area vegetation.

In coastal areas, wetland vegetation and soils, and their adjacent buffer zones, create an elevated barrier against storm surges and reduce wave energy through friction. While the ability of wetlands to absorb storm surges is widely accepted, there is considerable debate about the degree to which specific variables influence attenuation effectiveness. These variables included localized storm characteristics (e.g. speed, intensity, track) and wetland characteristics (e.g. topography, wetland size, vegetation roughness) (Wamsley et al 2010; Barbier et al 2013; Narayan et al 2016).

There are many studies that attempt to quantify the value of wetlands for flood control and storm damage prevention. One study in Middlebury, Vermont found that the Otter Creek wetland-floodplain complex reduces flood inundation costs by 92% compared to an area without a wetland-floodplain complex, a total value of \$126,000-450,000 annually (Watson et al 2016).

The risks associated with weather-related events are magnified in coastal regions where population densities are highest and flooding is common. Subsequently, coastal wetlands are highly valued for their ability to prevent storm damage. Wetlands provide additional ecosystem services beyond storm damage prevention that give them an advantage over human-made structures installed exclusively for coastal protection (Barbier 2015). For example, the monetary value of coastal assets and economies is staggering. The total output of the coastal economy in Massachusetts is approximately \$117 billion annually and represents 37 percent of annual gross state product (EEA and AAC 2011). In Massachusetts, approximately 49,352 ha/121,951 acres of wetlands occur within the average swath of coastal hurricanes (i.e. occur within 100 km/62 miles of the coast) (Costanza et al 2008). Wetland buffer zones protect both the functional integrity of the adjacent wetlands and provide additional naturally vegetated land to buffer the impact of severe storms.

Researchers have documented the substantial financial (as well as social) advantages to communities that protect wetland resources when significant storm events and floods occur, particularly in coastal regions. As noted above, Narayan et al. (2016) estimate that flood damages worth \$625 million were avoided due to the presence of coastal wetlands in communities hit by Hurricane Sandy. In Ocean County, New Jersey, flood loss costs were 20% lower for properties located just inland from salt marshes, compared to properties where salt marshes no longer exist between the property and the ocean. Buffer zones protect these natural infrastructure assets.

2.3.2.2 Literature Review: Recommended Buffer Zone Widths

Determining buffer widths to support storm damage prevention and flood control will depend on a site's location relative to floodplains, coastal storm flowage, and storm surge. The effects of climate change add to the complexity, as sea level rise, storm surge, and frequency of severe storms and large coastal and inland flooding events are increasing. Many municipalities are conducting vulnerability and resiliency studies to evaluate the effects of sea level rise and storm surges, along with flooding. EEA established the Municipal Vulnerability Preparedness grant program (MVP) in 2017 to assist communities to evaluate and plan for future vulnerabilities, including flooding. MassGIS has developed Climate Change Vulnerability

Maps, showing hurricane surge inundation zones for coastal communities. Commissions may wish to evaluate buffer zones and riparian corridors for their potential to mitigate changes in flooding associated with climate change.

2.3.2.3 Key Points

The key points from the literature sources described above can be summarized as follows:

- Buffer zones help control the rate at which water enters and leaves a wetland, thus helping to protect the flood storage and storm damage prevention ecosystem services/functions of wetland resource areas. Buffer zones can store excess water during floods, contributing to protection of human communities, associated infrastructure, and ecosystems.
- Buffer zone vegetation, particularly shrubs and trees, helps protect wetland resource area vegetation from storm damages.
- The flood control and storm damage prevention ecosystem services/functions of wetland resource areas and their buffers are becoming more important as our climate changes, because they provide climate resiliency ecosystem services that reduce damage to human communities and ecosystems resulting from floods and severe storm events. See Chapter 4.0.

The flood storage and storm damage prevention ecosystem services provided by wetland resource areas and buffer zones have significant economic and social value. Conservation commissions may wish to provide education to their communities, which may lead to greater support for state and local wetland protection laws and regulations and increased wetland conservation. See Chapter 4.0, particularly Section 4.6. Municipalities may wish to consult resources, such as desktop software tools, for assessing present and future flooding and storm damage risks as our climate changes and may wish to evaluate how these increasing risks intersect with existing natural infrastructure in their communities, such as wetland resource areas and their buffers. Conservation commissions may wish to work with others in the community to identify opportunities to enhance, create and restore natural infrastructure that provides flood and storm damage protection.

2.3.3 PROTECTED INTERESTS: Wildlife & Fisheries Habitat, Land Containing Shellfish

2.3.3.1 Science Supportive of WPA Ecosystem Interests

Buffer zones play a key role in protecting and supporting fish, shellfish, wildlife and their habitat. Upland buffer zones, which can include upland portions of riparian corridors, often function as core habitat (meaning essential for sustenance of life) for many semi-aquatic and terrestrial species. Some researchers (Hruby 2013) prefer the term “core habitat” to “buffer zone” because the adjacent upland habitat provides essential life-supporting habitat, in addition to buffering impacts to the wetland or water. Hruby (2013), in *Washington State Department of Ecology’s Update on Wetland Buffers: The State of the Science*, notes (in part):

Some ecologists are now calling buffers that provide critical life requirements for wetland dependent species “core habitats” rather than buffers ... The distinction is related to the idea that the buffer is not reducing (buffering) impacts to the functions provided by a

wetland. Rather, wetlands in proximity to adjacent upland habitat provide a critical function. The combination of the two habitat types is essential to a suite of species that would be absent from either habitat alone. These core habitats are essential to a number of wetland-dependent species, including amphibians. Inadequate quantity or quality of core habitat will increase the probability of local amphibian population extinction. In addition, some scientists suggest that the core habitat itself requires a buffer to protect its habitat functions from outside disturbances.

In *Buffer Zones and Beyond*, Boyd (2001) employs the same concept in using the term “life zone” to refer to upland habitat critical to survival of semi-aquatic species, and notes that Massachusetts Rivers Protection Act regulations (310 CMR 10.58) recognize this function of uplands adjacent to aquatic resources by regulating the Riverfront Area as a Resource Area, rather than as Buffer Zone.

As noted, the adjacent upland habitat ecotone (transitional zone between two different ecological communities) is considered essential to protecting biodiversity. Many studies document that several species of amphibians, reptiles, birds and mammals regularly use upland buffer zones, including riparian corridors, as core habitat for nesting, feeding, over-wintering and reproducing (Semlitsch and Jensen 2001; Semlitsch and Bodie 2003; Sheldon et al 2005). In Massachusetts, wetland buffer zones provide core habitat for 76% of freshwater wetland-dependent wildlife (Boyd 2001).

NUMBERS OF MA FRESHWATER WETLAND DEPENDENT (WD) SPECIES WITH UPLAND REQUIREMENTS				
	Species with Upland Requirements	Species without Upland Requirements	Total MA Freshwater WD Species*	% MA Freshwater WD with Upland Requirements
Reptiles	9	1	10	90%
Amphibians	19	1	20	95%
Mammals	14	0	14	100%
Birds	23	19	42	55%
Totals	65	21	86	76%

TABLE 3: *Wetland Buffer Zones and Beyond: Wildlife use of wetland buffer zones and their protection under the Massachusetts Wetland Protection Act. Modified from Boyd, L. (2001).*

Upland buffer zones, including riparian corridors, increase landscape connectivity by serving as corridors between different and diverse wetlands and upland ecosystems. Many wildlife species rely on multiple wetland ecosystems in the landscape to survive and forage for food (Gibbons 2003; Roe and Georges 2007; Harper et al 2008). One study found that a wide variety of reptile species use multiple wetlands separated by a mean minimum and maximum distance of 1637-5180 feet (Roe and Georges 2007). Sustaining many wetland species and overall biodiversity requires sustaining landscape connectivity, particularly as our climate changes (Anderson et al 2016a). However, as human development shifts from rural to urban, wetland mosaics in the landscape are shifting from clustered to isolated. Human density constrains the dispersal and movement of wetland organisms by making wetlands more isolated from one another (Gibbs 2000). Protection of buffer zones reduces fragmentation of the natural landscape.

Buffer zone width and cover type requirements vary depending on the specific needs of the species in question (Hruby 2013). Figure 5 provides information on width of buffer zone for a variety of species.

Buffer zones, including riparian corridors, enhance the protection of the adjacent wetlands, waterways and water bodies in the following ways, relative to wildlife habitat:

- Provide core habitat for species that utilize both wetlands/waterways/water bodies and uplands.
- Screen/protect wetlands/waterways/water bodies from human disturbance, including artificial light, noise and direct disturbance.
- Promote fish, shellfish, and wildlife climate resiliency by:
 - Maintaining wetland microclimate conditions, such as providing shade to help maintain cooler temperatures in wetlands and waters;
 - Providing corridors for species to migrate locally during extreme events and regionally over time in response to climatic changes;
 - Filtering pollutants, pathogens, nutrients and sediments out of stormwater prior to water reaching wetlands and waters; and
 - Providing a protective zone that allows the delineated jurisdictional boundary of wetlands to shift up and downgradient (due to drought or extended flooding) without losing protection of actual wetland.

Amphibians & Reptiles

The survival of amphibians and reptiles is highly dependent on the quality and quantity of upland buffer/riparian corridor habitat. Most amphibians are semi-aquatic, meaning they rely on both aquatic and terrestrial habitats to complete their life cycles. This makes them especially vulnerable to land development and environmental change. Global populations of amphibians and reptiles are continuing to decline as their suitable habitats dwindle (Gibbons et al 2000; Becker et al 2007).

Numerous studies have been conducted to determine how often wetland dependent amphibians and reptiles use terrestrial habitat, as well as how far these organisms travel from the wetland edge. Marbled salamanders (*Ambystoma opacum*), a native New England wetland species, use upland habitats beyond the regulated 100-foot Buffer Zone. Nearly 100% of adult marbled salamanders and 58-85% of juveniles can be found beyond the 100-foot Buffer Zone. Similarly, wood frogs (*Rana sylvatica*) and spotted salamanders (*Ambystoma maculatum*) of the northeastern United States require upland terrestrial habitat greater than 100-feet from the wetland edge for reproduction and survival (Homan et al 2004; Harper et al 2008). One report on Massachusetts's wildlife found that 95% of wetland dependent amphibians rely on upland areas (Boyd 2001).

Many species of turtles and snakes have high conservation priority in Massachusetts and depend on protected upland habitats. Freshwater turtles use upland habitats for nesting and terrestrial hibernation (Bennett et al 1970; Buhlman and Gibbons 2001), often at distances beyond 820 feet from the wetland edge (Burke and Gibbons 1995). In a Massachusetts study, twenty of twenty-six spotted turtles (*Clemmys guttata*) lay dormant in upland habitat for periods of two to ninety-three days while ten of twelve female

turtles nested in fields 250-1,020 feet from permanent wetlands (Milam and Melvin 2001). Semi-aquatic snake species also use upland habitat for nesting, often returning to the same burrow for multiple years (Roe et al 2003). In a study of five snakes and twenty-eight turtle species from around the world, core terrestrial habitat ranged from 415 to 950 feet from the edge of an aquatic ecosystem (Semlitsch and Bodie 2003b).

Waterfowl

Global wetland conservation in the 20th century was driven in large part by the need to protect waterfowl habitat (Matthews 2013). Waterfowl are important to the ecological processes of wetlands. Migratory and non-migratory birds increase local biodiversity through the transport of seeds and propagules among different wetlands (Amezaga et al 2002). Many species of waterfowl nest in riparian and upland areas adjacent to wetlands. In the southwestern United States, 50% of migratory and non-migratory birds nest in buffer areas adjacent to water bodies (Fisher and Acreman 2004). Recent studies indicate that factors such as type of vegetation in a buffer, whether the setting is urban or rural, and land uses within as much as 1 kilometer (km) of the wetland are significant to birds utilizing buffers (Hruby 2013). In Massachusetts, twenty-three wetland dependent bird species require upland habitats, twelve of which can be found nesting beyond 100-feet of the wetland edge (Boyd 2001). Wide buffers greater than 100 feet have been shown to protect bird species associated with coniferous upland forests, forest generalists, and specialized bird species whose abundance is associated with deciduous tree density (Shirley 2004).

In addition to nesting, waterfowl and wetland wildlife feed on plants and insects that live in upland habitats. Buffers provide refuge for flying insects that attract high numbers of insectivorous birds (Whitaker et al 2000). Dragonflies, for example, use upland habitat within 650 feet of the wetland edge, especially females and sexually immature adults (Bried and Ervin 2009). Some bird species feed on both aquatic and riparian insects. One study found that insectivorous bird population densities are positively correlated with the emergence of aquatic insects in riparian habitats (Gray 1993). Upland and riparian buffers also provide direct input of insects, plant material and fungi into aquatic ecosystems that are then used for food and shelter by freshwater fish (Pusey et al 2003). Aquatic and terrestrial ecosystems are tightly linked in relation to the food web and overall ecosystem functioning.

Mammals

Mammals use upland habitat for foraging, nesting, and travel corridors to wetlands (Doyle 1990). In Massachusetts, 100% of wetland-dependent mammal species use upland habitats, more than half of which use upland areas beyond 200-feet of the wetland edge (Boyd 2001). These include well-known species such as beaver (*Castor canadensis*), river otter (*Lontra canadensis*), muskrat (*Ondatra zibethicus*), mink (*Neovison vison*), and shrews (*Soricidae sp.*). Non-wetland dependent mammals also use upland areas as travel corridors to wetlands. Raccoon (*Procyon lotor*), moose (*Alces alces*), black bear (*Ursus americanus*), and white tail deer (*Odocoileus virginianus*) find food and cover in wetlands (May 2001).

Fish & Shellfish

Buffers, including riparian corridors, play a key role in maintaining ecosystem health and protecting fisheries and shellfisheries used for recreation and food. Buffers protect fish and shellfish health by removing water-borne pollutants such as fine sediment and nutrients. They also control pH levels and water temperature through groundwater input, shading and the deposition of organic debris. Aquatic organisms are sensitive to changes to their environment.

Regarding fish, excess suspended and deposited fine sediment reduces reproductive success, abrades gills, stunts development, reduces food availability, modifies migration patterns, decreases resiliency to disease and reduces predatory success for visual hunters (Kemp et al 2011). In macroinvertebrates, excess fine sediment clogs substrate habitat, inhibits respiration, impedes filter feeding, reduces food availability and restricts movement. Changes in oxygen gradients and water pH are also common in areas where sediment pollution occurs (Wood and Armitage 1997). Nutrient pollution from inputs of nitrogen and phosphorous also have deleterious effects on aquatic organisms. Eutrophication, fish kills, biodiversity loss and toxic algal blooms are associated with nutrient pollution (Carpenter et al 1998). Buffers also reduce fecal coliform levels (Sullivan et al 2007) which can accumulate in shellfish used for human consumption (Hood et al 1983).

Climate Adaptation and Resiliency

Examples of how buffers, including riparian corridors, increase climate adaptation and resiliency for wildlife, fish, shellfish and their habitats include (see Chapter 4.0 for additional information):

- Providing shade to adjacent wetlands and waters, thus protecting resource area microclimates and temperature/humidity gradients on the landscape;
- Increasing landscape connectivity;
- Supporting biodiversity by providing diversity of habitat types;
- Reducing other stressors, such as influxes of waterborne contaminants and nutrients, and limiting invasive species intrusion into wetlands and waters;
- Providing additional flood storage capacity and upgradient land for migration of freshwater wetland functions under flood/heavy precipitation conditions; and
- Providing upgradient land for inland migration of tidal wetlands as sea level rises.

2.3.3.2 Literature Review: Recommended Buffer Zone Widths

Developing recommended Buffer Zone widths for fish and wildlife can be challenging, and in many cases impracticable, given species-specific habitat requirements. That said, reasonable conclusions can often be reached regarding general Buffer Zone widths to contribute to the protection of these Interests of the Act. For perspective, in *Washington Department of Ecology: Update on Wetland Buffers: The State of the Science* (2013):

“The WA Department of Ecology study documents the importance of buffers in providing essential upland habitat for species that utilize wetlands/waters as well as uplands, and for providing diversity of habitat as a transition zone between wetland and upland. This

study affirms the idea that uplands adjacent to wetlands and waters are core, life-supporting habitat for many wetland and water dependent species, and do not serve only as buffers for the adjacent wetlands and waters. As indicated in Figure 4 (i.e. MACC Guidebook Figure 5), just under 400 feet is identified as a minimum “core habitat” width, and 800+ to 3,700 feet is identified as optimal “core habitat” width for wildlife protection. They recommend the following modifications to buffer widths based on wetland function and adjacent land use:

- 25 to 75 feet (8 to 23 m) for wetlands with minimal habitat functions and low-intensity land uses adjacent to the wetland;
- 75 to 150 feet (15 to 46 m) for wetlands with moderate habitat functions and moderate or high-intensity land uses adjacent to the wetland; and
- 150 – 300+ feet (46 to 92+ m) for wetlands with high habitat functions, regardless of the intensity of the land uses adjacent to the wetland.”

Environmental Law Institute’s *Planner’s Guide to Wetland Buffers for Local Governments* (2008) notes that an earlier 2003 Environmental Law Institute study found (in part) that,

“... effective buffer sizes for wildlife protection may range from 33 to more than 5,000 feet, depending on the species.”,

But their 2008 Buffer Distance by Function figure (See Figure 6) indicates minimum and most effective buffer widths as: “... Wildlife Habitat: 45 feet minimum, and 100 – 1000+ feet for most effective results.”

2.3.3.3 Key Points

The key points inferred from the literature sources described above can be summarized as follows:

- Some researchers (Hruby 2013) prefer the term “core habitat” to “buffer zone” because the adjacent upland habitat provides essential life-supporting habitat, in addition to buffering impacts to the wetland or water.
- There is abundant research and information regarding the upland habitat requirements of specific species in Massachusetts (e.g., Boyd 2001; DeGraaf and Yamasaki 2001).
- Recommended widths for buffer zones, including riparian corridors, for wildlife protection are highly variable and species dependent. Most studies agree, however, that a 100-foot Buffer Zone does not provide a large enough adjacent upland habitat for a variety of species across numerous taxa (Boyd 2001; Gamble et al 2006; Roe and Georges 2007; Harper et al 2008; Rittenhouse and Semlitsch 2009; Marczak et al 2010; Hruby 2013; NHANRS Legislative Committee 2017). This is especially true in highly developed areas where additional environmental stresses are present. Section 2.3.3.2 provides additional buffer width information relative to wildlife habitat.
- In many cases, increasing buffer width can be an effective strategy for protecting wildlife with upland habitat requirements. It is unlikely, however, that policies that use buffer width alone are feasible and effective at the state level (Hruby 2013).

- Buffer zone vegetation, particularly shrubs and trees, helps protect wetland resource area vegetation and the associated fish, shellfish, and wildlife habitat, as well as providing shade to adjacent wetlands and waters, thus protecting fish, shellfish and wildlife habitat microclimates.
- The fish, shellfish and wildlife habitat functions of wetland resource areas and their buffers are becoming more important as our climate changes, because they provide climate resiliency ecosystem services that protect fish, shellfish and wildlife ecosystem services for human communities as well as for the fish, shellfish and wildlife themselves. See Chapter 4.0.

The fish, shellfish and wildlife habitat ecosystem services provided by wetland resource areas and buffer zones have significant economic and social value. Conservation commissions may wish to provide education to their communities, which may lead to greater support for state and local wetland protection laws and regulations and increased wetland conservation. See Chapter 4.0, particularly Section 4.6. Municipalities may wish to consult available resources for assessing present and future risks to fisheries, shellfisheries and wildlife habitat as our climate changes, and may wish to evaluate how these increasing risks intersect with existing natural infrastructure in their communities, such as wetland resource areas and their buffers. Conservation commissions may wish to work with others in the community to identify opportunities to enhance, create and restore natural infrastructure that provides protection of fisheries, shellfisheries and wildlife habitat.

3.0 REVIEWING A PROJECT IN THE BUFFER ZONE

3.1 Decision Making Under the WPA Regulations: 310 CMR 10.24(1) and 10.53(1)

WPA regulations 301 CMR 10.24(1) and 10.53(1) provide a regulatory framework for project review (see following paragraph), but because the Buffer Zone is a “review” area under the WPA, as opposed to a Resource Area, the WPA regulations do not provide specific performance standards for Buffer Zone activities. In the absence of regulatory performance standards, conservation commissions can base findings and ensuing decisions on the body of science (see Chapters 2.0 and 4.0) that indicates how reliant wetland, waterway and water body functioning is on maintenance of a vegetated, and preferably undisturbed, Buffer Zone. Commissions can require applicants to demonstrate how the proposed work ensures that the Interests of the Act are protected (See Section 5.4, which discusses “burden of proof”), given that Buffer Zones are integral to the functioning of adjacent wetlands and waters. However, scientific recommendations for buffer zone width may only be implemented within the parameters of WPA regulation, which is 100 feet from the Resource Area boundary. Scientific literature often recommends buffer widths more than, and, in some cases, less than, 100 feet depending on the ecosystem service or function that is being protected. This is particularly true for wildlife habitat, as many wetland and water-dependent species require significantly more than 100 feet of adjacent upland to sustain essential life cycle activities.

Most work (other than Exempt Minor Activities, see Section 1.3.1.1 and Appendix B) in the Buffer Zone is subject to preconstruction review to ensure the protection of the associated Resource Area. While the regulations do not contain specific performance standards for the Buffer Zone, the provisions at 310 CMR 310 CMR 10.24(1) (coastal) and 10.53(1) (inland) provide a framework for the review of work in the Buffer Zone:

For work in the Buffer Zone subject to review under 310 CMR 10.02(2)(b)3. [i.e. Buffer Zone activities not identified as exempt minor activities], the Applicant may choose to file a Request for Determination of Applicability if they are unsure as to whether or not a Notice of Intent is needed. Following review of the Request for Determination of Applicability or Notice of Intent, and when preparing an Order of Conditions, the Issuing Authority shall impose conditions to protect the interests of the Act identified for the adjacent Resource Area.

The potential for adverse impacts to Resource Areas from work in the Buffer Zone may increase with the extent of the work and the proximity to the Resource Area. The Issuing Authority may consider the characteristics of the Buffer Zone, such as the presence of steep slopes, that may increase the potential for adverse impacts on Resource Areas. Conditions may include limitations on the scope and location of work in the Buffer Zone as necessary to avoid alteration of resource areas. The Issuing Authority may require erosion and sedimentation controls during construction, a clear limit of work, and the preservation of natural vegetation adjacent to the Resource Area and/or other measures commensurate with the scope and location of work in the Buffer Zone to protect the interests of M.G.L. 131, s. 40. Where a Buffer Zone has already been developed, the Issuing Authority may consider the extent of existing development in the review of subsequent proposed work and, where prior development is extensive, may consider measures such as the restoration of natural vegetation adjacent to a Resource Area to protect the interests of M.G.L. 131, s. 40. The purpose of preconstruction review of work in the Buffer Zone is to ensure that adjacent Resource Areas are not adversely affected during or after completion of the work.

This regulatory provision governing the review of work in the Buffer Zone acknowledges the critical role played by the Buffer Zone in the protection of Resource Areas, while also emphasizing that it is the Resource Areas and their Interests that are protected, not the Buffer Zone per se. The scope of review should be commensurate with the scope of the proposed work and its impacts; alteration of a very limited area of Buffer Zone on its upland edge generally will require less attention than a large project proposing extensive alteration. The regulatory provision provides a framework for review of work in the Buffer Zone, based essentially on three components: the type and characteristics of the Resource Area, the characteristics of the Buffer Zone, and the scope and location of the proposed work. If the Applicant is unsure about whether or not they need to file a Notice of Intent for work in the Buffer Zone, they may file a Request for Determination of Applicability, which is a shorter and simpler filing form ([See MACC Handbook](#) for further explanation of Request for Determination of Applicability).

3.1.1 Resource Area and Protected Interests

Review of work in the Buffer Zone begins with an understanding of the adjacent Resource Area(s). As a preliminary matter, Commissions should confirm that the Resource Area(s) has a Buffer Zone (see the list at 310 CMR 10.02(1)) and that the Buffer Zone is not within Riverfront Area (where the Riverfront Area performance standards apply). Some Coastal Resource Area WPA regulations (see Dunes at 310 CMR 10.28 and Salt Marsh at 310 CMR 10.32) include performance standards that prohibit adverse impacts to the Dune or Salt Marsh resulting from activities in both the 100-foot area adjacent to the Resource Area (i.e. Buffer Zone) as well as the Resource Area itself. WPA 310 CMR 10.32(3) states,

A proposed project in a salt marsh, on lands within 100 feet of a salt marsh, or in a body of water adjacent to a salt marsh shall not destroy any portion of the salt marsh and shall not have an adverse effect on the productivity of the salt marsh. Alterations in the growth, distribution and composition of the salt marsh vegetation shall be considered in evaluating adverse effects on productivity.

For instance, applying nitrogen-based fertilizer within the 100-foot Buffer Zone to a Salt Marsh could potentially be prohibited on the basis of the scientific evidence that runoff containing nitrogen could lead to elevated levels of nitrogen in salt marsh soils, and it is well documented that elevated levels of nitrogen can cause damage to the root systems of Salt Marsh vegetation, which then leads to decreased productivity of the Salt Marsh.

Bordering Land Subject to Flooding (i.e., the 100-year floodplain) does not have a Buffer Zone under the WPA, but a Buffer Zone associated with another Resource Area adjacent to Bordering Land Subject to Flooding could extend into uplands beyond the Bordering Land Subject to Flooding (See Figure 13 on Page 106 for illustration).

It is important to confirm that the 100-foot Buffer Zone boundary shown on a plan has been accurately located by confirming that the associated Resource Area boundary has been accurately delineated.

According to recent research (Adamus 2007; Hruby 2013, Zhang et al. 2010) and others, key characteristics of the adjacent Resource Area, the Buffer Zone, the proposed work or activity, and other considerations/factors contribute to how activities in the Buffer Zone impact the functioning of the adjacent Resource Area, as detailed in the following Sections.

3.1.2 Key Characteristics of Adjacent Resource Area

The characteristics and condition of the adjacent wetland, waterway and/or water body are important in determining the impact of the proposed Buffer Zone or Riverfront Area activity on the adjacent regulated Resource Area. The following factors associated with the adjacent Resource Area can be evaluated to assess potential impacts from Buffer Zone/Riverfront Area activities:

- Biological condition/level of existing disturbance;
- Relative sensitivity of the Resource Area:
 - Is the Resource Area a vernal pool, and if so, is it certified or not?
 - Are rare species or their habitat present?
 - Is the area part of an Area of Critical Environmental Concern?
 - Is the area part of an Outstanding Resource Water?
 - Is a cold-water fishery present?
 - Is the Resource Area particularly vulnerable to erosion, sedimentation, or contamination?
- Soils:
 - erodibility;
 - tillage, compaction, intermittent flooding all increase erodibility; and
 - depth.
- Vegetation:
 - cover type;
 - density;
 - height; and
 - wooded wetlands and wetlands lacking surface water host fewer disturbance-sensitive water birds than shallow wetlands with open water.
- Hydrology:
 - presence of vernal pool (is the pool certified or uncertified?) or other sensitive habitat/ecosystem;
 - presence of open water in resource area
- Wildlife, fish, shellfish habitat & usage:
 - species and sensitivity of wildlife, fish, shellfish; and
 - rare/unique species status.

Other characteristics of the adjacent Resource Area that are important to consider:

- Type of Resource Area – Bank and/or Land Under Waterbody and Waterway in an open water such as a lake or pond, a headwater intermittent stream and/or Bordering Vegetated Wetland?
- Interests of the Act that are presumed to be significant for the adjacent Resource Area.
- Biological Condition/Level of Existing Disturbance – is there eutrophication or other existing water quality issues, is the Resource Area entirely undisturbed?

Note that these characteristics are directly related to the Interests of the Act and are generally applicable to Resource Areas with Buffer Zones. Review of work in the Buffer Zone will generally be more efficient with a focus on the regulatory text at 310 CMR 10.53(1) and 10.24(1) (discussed in Section 3.1) rather than attempting to apply the Interests to the Resource Area and its Buffer Zone.

3.1.3 Key Characteristics of Buffer Zone

The goal of the Commission's review is not to protect the Buffer Zone per se, but to identify characteristics of the Buffer Zone that are relevant to the protection of the adjacent Resource Area. Features of the Buffer Zone generally can be observed and identified in a site visit and may also be described in the filing and in desktop resources, such as MassGIS, NRCS Web Soil Survey, and FEMA mapping. Review of the filing and desktop resources is advisable prior to the site visit.

The following factors associated with the Buffer Zone could be considered when assessing potential impacts from Buffer Zone activities on the adjacent Resource Area (Adamus 2007; Hruby 2013, Zhang et al 2010, and others):

- Vegetation type, condition, height, width, land use intensity. Is the Buffer Zone already developed or partially developed? What vegetation is present, especially noting the cover type (trees, shrubs, grass and the presence of invasive species)?
- Surface roughness;
- Biological condition/level of existing disturbance;
- Water source (unpolluted or polluted);
- Flow pattern (diffuse or concentrated/channelized);
- Slope:
 - percent slope (10% slope is most effective for improving water quality);
 - length of slope;
- Soil type:
 - erodibility;
 - texture and permeability (permeability influences flow pattern);
 - moderately coarse textures, glacial outwash is preferable;

- fine-textured clays saturate quickly, leading to surface flow, concentration of flow;
- coarse textured soils are too permeable and tend to lack organic content. Lack of organic content leads to poor retention of pollutants;
- Subsurface water regime (soil saturation, groundwater flow paths);
- Subsurface biogeochemistry (supply of organic carbon, nitrate inputs); and
- Depth.
- Location of buffer in relation to inflows of water;
- Width needed to deter invasive species, support specific species utilizing adjacent wetlands and waters;
- Area contributing to buffer/riparian corridor relative to buffer/riparian corridor size;
- Type, amount and dosing of pollutants/nutrients entering buffer zone/riparian corridor;
- Is the upland area adjacent to the Buffer Zone undeveloped or is existing development contributing pollutants to the Resource Area through the Buffer Zone?
- Scientifically recommended and jurisdictional Buffer Zone width associated with the Interests of the Act presumed to be significant to the adjacent Resource Area.

3.1.4 Potential for Impacts from Proposed Work in the Buffer Zone

Just as the characteristics of Buffer Zones may vary widely, so too does the proposed work. The type and extent of work has a direct bearing on the potential for adverse impacts to the Resource Area, as clearly expressed in the governing regulatory provisions. A Commission should understand the proposed work as shown on the plans, and a site visit should clarify the relationship of the proposed work to the characteristics of the Buffer Zone.

The following factors associated with the proposed Buffer Zone activity could be considered to assess potential impacts from these activities on the adjacent Resource Area:

- What is the type of proposed work, such as installing pavement for a driveway, planting lawn, construction of a detention basin for stormwater management, other type of structure or change in land use?
- Scope of proposed work – how large an area will be altered?
- Location of proposed work in the Buffer Zone – distance to Resource Area?
- Location of proposed work in the Buffer Zone – within developed or undeveloped area?
- Impacts from proposed work, such as
 - loss of vegetation, including loss of capacity to detain, filter, transform, and infiltrate runoff, pollutants, nutrients,
 - generation of pollutants or excess nutrients from runoff,

- changes in shading from trees that could affect the Resource Area,
- changes to leaf litter, woody debris, organic matter inputs to adjacent Resource Area
- creation of hazards for or barriers to wildlife/fish movement;
- frequency of disturbance;
- Cumulative impacts.

3.1.5 Other Characteristics/Factors to Consider

Weather and climate can play a significant role in determining how a Buffer Zone activity might impact the adjacent Resource Area, particularly during the construction phase of a project, including:

- precipitation patterns;
- rainfall pattern influences flow pattern (one of the most important determinants of effectiveness of buffers in terms of water quality); and
- storm events.

Landscape position and geomorphology can play a significant role in determining how a Buffer Zone activity might impact the adjacent Resource Area, including:

- part of wetland mosaic (i.e. landscape with high density of wetlands, also referred to as wetland complexes);
- capacity to act as a plant and wildlife migration corridor;
- location in lower or upper watershed (some functions differ depending on location within the watershed)
- geomorphology of wetland, water and buffer/riparian corridor;
- does the wetland, water, buffer complex provide regionally unique ecosystems or ecotones (See Appendix A for definition)?
- characteristics of the watershed?

Adjacent land use can play a significant role in determining how a Buffer Zone activity might impact the adjacent Resource Area, including:

- type of land use and characteristics, including density of development, and percent pervious/impervious cover;
- nutrient and pollutant type and loading;
- new development vs re-development; and
- historic land uses/potential contamination.

3.1.6 Implementation of the Regulatory Provisions for the Review of Work in the Buffer Zone

When reviewing work in the Buffer Zone, Commissions will want to consider a number of factors, and then develop project-specific Special Conditions. The following sections provide suggestions in this regard.

3.1.6.1 Project Review Considerations

- As an initial step, Commissions should always review a permit application carefully, including the plans and application documentation, to fully understand the scope and potential impact of proposed activities on the Interests of the Act, and the proximity of said work to Resource Areas and within the Buffer Zone.
- Commissions should request additional information from the Applicant, should it be needed to understand the impact of proposed activities on the Interests of the Act, the Resource Areas, and the ability of the Buffer Zone to protect them.
- Conduct a site inspection, paying attention to the characteristics of the Resource Area, characteristics and condition of the adjacent Buffer Zone, including the slope between the limit of work and the Resource Area. See Chapter 2.0 for additional information.
- Things to consider:
 - Will the project substantially reduce the capacity of the Buffer Zone to slow, detain, filter, store and infiltrate runoff prior to reaching the Resource Area(s)? (e.g. change in grading, change in vegetative cover, change in ability to recharge or infiltrate water)
 - Will the project substantially reduce the capacity of the Buffer Zone to protect the fisheries, shellfisheries and wildlife habitat functions of the Wetland Resource Area(s)?
 - Will the project substantially reduce existing Buffer Zone vegetation that provides protection to Resource Area(s) vegetation, thus potentially reducing the functional capacity of the adjacent Resource Area(s)? (e.g. change in filtering capacity, change in overstory)?
 - Is the existing or proposed undisturbed Buffer Zone suitable to maintain sediment, pollutant, pathogen, and nutrient removal capacity of the adjacent Resource Area(s)? (e.g. what is the tributary watershed size being directed to the buffer zone? What are the potential nutrient loads? Is there mitigation to avoid, minimize, and reduce loading?)
 - Is the existing or proposed undisturbed Buffer Zone suitable to maintain the desired flood storage, fisheries, shellfisheries, and/or wildlife habitat capacity of the adjacent Resource Area(s)?
 - Can the project be reasonably shifted or modified to allow work and also the necessary Buffer Zone protection of Resource Area(s) sediment, pollutant, pathogen and nutrient removal, flood control, storm damage, protection of fisheries, shellfisheries and wildlife habitat functions?

- Can the project be conditioned to allow the work and still protect the Resource Area(s) and associated Interests? (e.g. has mitigation been provided, such as invasive species management, provision of native plantings, provision of a continuous buffer around a Resource Area)

Municipalities may wish to consider Bylaw/Ordinance changes to address increasing risks to water quality, water supply, fisheries, shellfisheries and wildlife, and increased risks from flooding and storm damage associated with increasing drought and flooding as our climate changes.

3.1.6.2 Preparing Project-Specific Conditions

After the Commission has gained an understanding of the characteristics of the adjacent Resource Area, the characteristics of the Buffer Zone, the scope and extent of the proposed work, and other relevant factors, it must determine what conditions are necessary to adequately protect the adjacent Resource Area from adverse impacts.

WPA Buffer Zone regulations can be implemented considering current research about the importance of the Buffer Zone, as well as the regulatory framework provided at 301 CMR 10.24(1) and 10.53(1). Based on the regulatory provisions and scientific studies, well prepared Conditions will:

- Include a clear limit of work.
- Include erosion and sedimentation controls, commensurate with the scope of work, proximity to the Resource Area, erodibility of soils, and steepness of slopes; the proposed work should comply with the Stormwater Management Standards to the extent applicable.
- Require the preservation of natural vegetation in the Buffer Zone adjacent to the Resource Area. The width of the natural vegetation is not the sole factor in ensuring the capacity of the Buffer Zone to protect Resource Areas, and applicants may demonstrate that the proposed work supports an exception. However, as noted in Chapter 2.0, studies (Hruby 2013) generally support a minimum of 20 feet for sediment removal and 30 feet for nutrient removal, with a greater width of more than 50 feet for steep slopes and for either fine-textured/clay or coarse-textured soils. Wildlife habitat protection generally requires greater buffer zone widths, with significant variability depending on species, as discussed in Chapter 2.0. Work related to relatively low intensity development, such as the construction of a single-family house on a small generally level lot within the Buffer Zone, may be conditioned to retain natural vegetation adjacent to the Resource Area consistent with site constraints. Work related to relatively high intensity development, such as commercial, industrial, or institutional facilities, or lower intensity development on large lots, should be sited to preserve natural vegetation adjacent to the Resource Area of no less than 50 feet, with a greater area consistent with site conditions and development intensity. The averaging of the width of natural vegetation adjacent to the Resource Area may be allowed where appropriate. For instance, encroachment within 50 feet of the Resource Area may be considered if greater than 50 feet of natural vegetation is preserved elsewhere on the site, so that a Buffer Zone width of an average of 50 feet is achieved. The idea behind this is that it may be possible to provide a similar level of overall functioning with this approach, and it allows the property owner some additional

flexibility to accommodate project designs. However, averaging of Buffer Zone width should not be done in cases where doing so would lead to reduced protection of the Interests of the Act and the regulated Wetland Resource Areas.

- Based on a finding that there is important wildlife habitat in the adjacent Resource Area, require an undisturbed corridor appropriate for the species. A minimum width suggested by scientific studies (Hruby 2013) is 25 to 75 feet for minimal habitat functions and low intensity land uses. Greater widths are recommended for wetlands with moderate or high habitat functions and/or moderate or high intensity land uses adjacent to the wetland (further discussed in Chapter 2.0). The necessary corridor will be highly species-dependent, with attention to rare species advised.
- Where the vegetation within the Buffer Zone contains invasive plant species, allow the removal of invasive species and the planting of native species, consistent with protection of the Resource Area.
- Where the Buffer Zone is extensively developed, include the restoration of natural vegetation adjacent to the Resource Area in an amount and width sufficient to enhance the capacity of the Buffer Zone to detain and filter pollutants, nutrients, and sediment, prior to flow reaching the Resource Area, typically a minimum of 20 to 30 feet in width. Cover type, species of plants, soil and hydrology should be considered to ensure successful restoration of the natural vegetation.
- Where proposed work is extensive in scope and impact, such as a commercial facility with parking, and the adjacent Resource Area contains sensitive areas such as vernal pools, scientific studies (see Chapter 2.0 and References) may support conditions that preclude the work as proposed, resulting in a denial. It is useful to note that MA WPA regulations only recognize certified vernal pools. Bylaws and Ordinances may include protections for uncertified or potential vernal pools.
- Particularly for larger, more complex projects and projects involving construction of mitigation and/or restoration areas and invasive species control, include construction and post-construction monitoring by qualified personnel. This monitoring provides an opportunity to ensure that unapproved Buffer Zone encroachment does not occur during the construction and post-construction time frames.

Generally, consistent with the purpose of review stated in 310 CMR 10.24(1) and 10.53(1), a Commission should ensure that the proposed work in the Buffer Zone will not adversely affect the adjacent Resource Area during construction or after completion of the work. The review should consider the Resource Area and associated Interests, the characteristics of the Buffer Zone, the scope and location of the proposed work, including construction period activities, and other factors such as weather during construction. Within the Buffer Zone, the proposed work, including any mitigation measures, should not result in the impairment of the capacity of the Resource Area to protect the Interests of the WPA.

3.2 Decision-Making Under Existing Local Wetland Bylaws and Ordinances

When municipalities have existing Bylaws and Ordinances, conservation commissions can draw on the scientific literature provided in this Guidebook as well as the approach outlined in Section 3.1 when preparing Findings, Decisions, and Orders of Conditions. If conservation commissions wish to incorporate protection of additional ecosystem services/functions and/or ecosystem services/functions that previously have not been associated with the Interests of the Act or with provisions of their Bylaw/Ordinance, they can utilize the scientific documentation and logic identified in Chapters 2.0, 3.0 and 4.0 of this Guidebook. Additionally, they can consider amending their Bylaw/Ordinance to explicitly protect additional, or previously unrecognized, ecosystem services and functions.

For example, some Commissions regulate aesthetics and recreation as part of their Bylaws and Ordinances. The scientific documentation referenced in this Guidebook can aid in reviewing projects associated with development of trails, view clearing and vegetation management.

3.2.1 Science-based Performance Standards in Regulations Under a Bylaw/Ordinance

While the WPA regulations do not include performance standards for Buffer Zones, local Bylaws/Ordinances may include them, if they regulate Buffer Zones as actual Resource Areas and establish presumptions of significance for protection of ecosystem services/functions/Interests of the Act. To be both functionally effective and defensible in court, performance standards should be based in science, and should be supported by presumption of significance and burden of proof statements.

Buffer Zone performance standards can address the following aspects of proposed projects:

- Potential alteration of and impact to ecosystem services/functions/Interests of the Bylaw/Ordinance identified in the presumption of significance statement for the Buffer Zone and/or Riverfront Area;
- Distance from adjacent Resource Area;
- Nature, scale, frequency of proposed alteration or impact;
- Anticipated expansion of flood and storm surge inundation and changes associated with sea level rise;
- Significance of impact and potential contribution to cumulative impacts;
- Characteristics and condition of the Buffer Zone or Riverfront Area; and
- Characteristics and condition of the adjacent Resource Area.

Often these various considerations are mediated by the establishment of different levels of protection depending on distance of a proposed activity from an adjacent Resource Area boundary (i.e. Buffer Zone width), modified by consideration of the nature and scale of the activity, with further modification of performance standards based on the characteristics and condition of the adjacent Resource Area and the Buffer Zone/Riverfront Area. Three common approaches to regulating Buffer Zone widths are “fixed width” Buffer Zones, “variable width” Buffer Zones, and “multi-zone” Buffer Zones.

- Fixed width Buffer Zones have the advantage of being simple and easy to understand, evaluate, regulate, and administer. Their disadvantage is that they can cause stakeholder dissatisfaction due to over-regulating or under-regulating, depending on specific site conditions, as the fixed Buffer Zone width may or may not be appropriate for any given project or site. For instance, if the fixed width is the result of a political compromise rather than derived from the scientific literature, it may not be effective in protecting the ecosystem services, functions, and/or Interests of the Act that it was intended to protect, while giving the public a false sense that appropriate protective measures have been taken. Likewise, if the Buffer Zone width is based on a “worst case” scenario, inevitably there will be conditions where such a wide Buffer Zone is not needed, and public support for the Bylaw or Ordinance could dissipate (Berkshire Regional Planning Commission for MassDEP, 2003).
- Variable width Buffer Zones identify a minimum width Buffer Zone based on scientific literature, while also taking into consideration the nature of the proposed work and site-specific conditions. For instance, construction of a structure and conversion of vegetated land to impervious surfaces would be restricted to the outer part of the Buffer Zone or Riverfront Area, whereas grading followed by revegetation with native species would be permitted at closer proximity to the adjacent Resource Area. Alternatively, the minimum buffer width would be expanded to provide additional protections if protected rare species were known to occur in the adjacent Resource Area. While more flexible, variable-width buffers require more resources to implement and can lead to disagreements among stakeholders.
- The multi-zone Buffer Zone width approach establishes a Buffer Zone that is comprised of multiple, layered setbacks. Often, the first setback is a no-work/no-disturb/no-alteration zone, followed by a second limited work/no-build/no-structure zone and then a third development-with-conditions zone in the outer portion of the Buffer Zone. Multi-zoned approaches can include fixed-widths or variable widths for each setback, and therefore is more structured than the variable-zoned approach. The multi-zoned approach offers various levels of protection from the wetland edge but can be difficult for non-professionals to interpret and hard to implement in urban settings (City of Boulder and Biohabitats, Inc. 2007 and Hawes and Smith 2005).

In Massachusetts, some Commissions rely on “no disturb” zones within the Buffer Zone to Resource Areas, often set at 25 feet or 50 feet. This approach offers consistency and predictability. Some Commissions review Buffer Zone projects entirely case-by-case. Some use a general “no disturb” zone and then identify exceptions which may either contract or extend the width. Some Commissions focus primarily on work in Resource Areas, with only cursory review of work in the Buffer Zone. Local conditions vary, and the practices of Commissions may be unique.

3.2.2 Science-based Findings in a Permit Under a Bylaw/Ordinance

Regarding the Buffer Zone, the Findings section of an Order of Conditions is an opportunity for conservation commissions to provide their rationale for placing Conditions on activities within the Buffer Zone. Should the Commission’s decision be appealed, the Findings are part of the written record that

supports the Commission's decision, and therefore must be considered by the adjudicating authority. Well prepared Findings will:

- List all Resource Areas and Buffer Zones affected by the proposed project, noting boundaries of impacted areas and extent of disturbance to each area.
- Describe the existing biological condition of the Buffer Zone, adjacent Resource Area, and overall site.
- Describe and quantify the proposed project and impacts (both temporary and permanent) to Resource Areas and Buffer Zone, including distances of activities in the Buffer Zone from Resource Areas.
- Identify the Resource Areas and associated Interests of the Act and Bylaw/Ordinance that are protected by the existing Buffer Zone, and applicable Performance Standards.
- If available and relevant, include scientific citations that support Findings (which adds weight to the Findings).
- Identify Buffer Zone area anticipated to be necessary to protect the adjacent Resource Areas and Interests of the Act and Bylaw/Ordinance.
- Identify Bylaw/Ordinance Buffer Zone requirements that apply to the project, such as "No Disturb" or "No Build" Zones and specific activities that are excluded from all or portions of the Buffer Zone.
- Identify Buffer Zone activities that are exempt under state or local jurisdiction or have been authorized through a Bylaw/Ordinance waiver process. Identify any "limited project"² activities.
- List mitigating activities, including requirements for restoration of the Buffer Zone following temporary disturbance.

² Limited Projects are categories of activities within the WPA regulations (and some Bylaws/Ordinances) which can proceed without fully meeting the affected resource area(s) General Performance Standards. The General Performance Standards explain which type of alteration is or is not allowed, any exceptions to this, and the criteria permitted work must meet. Put another way, the Limited Project regulations of the WPA (which can be found under 310 CMR 10.53(3)), establish provisions for conservation commissions or MassDEP to allow certain activities even though they may not meet the General Performance Standards otherwise required for work in certain wetland resource areas, such as the 5,000 square-foot limitation on alteration of BVW. While the term "limited" may suggest small, many large and complex projects, which typically involve greater and largely unavoidable impacts on wetland resource areas, are filed as "limited" projects. The term "limited" actually refers to the relatively limited situations in which they apply.

4.0 LOCAL BYLAWS AND ORDINANCES: CLIMATE SCIENCE AND OTHER CONSIDERATIONS

In creating local Bylaws and Ordinances, municipalities have the opportunity to protect additional interests/ecosystem services/functions, such as recreation, aesthetics, and education, and to explicitly acknowledge some interests/ecosystem services/functions that are inherently protected (in part) under the WPA through the Interests of the Act, but are not fully acknowledged, such as carbon storage and sequestration and climate adaptation and resiliency. The subsections below provide more specific information in this regard.

Wetland Buffers and Climate Change

Wetland buffers will enable local communities to protect themselves from known hazards associated with global climate change. In some regions, climate change will produce more extreme storm events, increase the number and intensity of floods, and alter the infiltration and conveyance capacity of stormwater and natural wetland systems. Sea level rise will threaten coastal communities, which depend upon the storm-buffering effects of coastal wetlands. Climate change will also change the volume and timing of snowmelt, alter groundwater supplies, and produce drought effects, making healthy wetland function even more critical for water supply and watershed resilience. An ordinance that protects wetland buffers will moderate the effects of drought and protect private and public property.

Direct quotation from: Environmental Law Institute's Planner's Guide to Wetland Buffers for Local Governments (2008)

4.1 Climate Change in Massachusetts

Climate change is affecting Massachusetts wetlands, waters, buffers, ecosystems and communities. The Massachusetts Executive Office of Energy and Environmental Affairs (EEA) provides a [summary](#) of anticipated climate changes in Massachusetts. Many of these changes have implications for wetlands, waters, and buffer zones, including riparian corridors, and for the surrounding communities. At the



Source: MACC Fundamentals for Conservation Commissioners Training Program – Unit 104

national level, the [Fourth National Climate Assessment](#) (US Global Change Research Program 2017) and the [National Climate Report](#) (NOAA 2018) provide information on climate change in the United States. The recently released [Intergovernmental Panel on Climate Change report](#) (Allen et al 2018) provides a synthesis of more than 6,000 scientific studies on global climate change.

Massachusetts is a national leader in climate change policy and regulation, both regarding greenhouse gas emissions reduction and promoting climate adaptation and resiliency for Massachusetts

communities and citizens. Major directives and initiatives in this area include the [2008 Global Warming Solutions Act \(GWSA\)](#) and [Executive Order 569](#) (*Establishing an Integrated Climate Change Strategy for the Commonwealth*).

The GWSA requires greenhouse gas emission reductions from each sector of the economy to increase the chance that the worst effects of climate change can be avoided. The GWSA led to the preparation of the 2011 [Massachusetts Climate Change Adaptation Report](#), which provides initial guidance on how to support climate adaptation for communities, wetlands, waters, and other ecosystems.

Executive Order 569 requires the establishment of a framework for municipalities to assess vulnerabilities to climate change and develop adaptation options. The state is providing technical assistance and funding for adaptation assessments, adaptation planning and implementation of adaptation measures through the [Municipal Vulnerability Preparedness \(MVP\) Program](#). While not specifically mentioned in the executive order, nature-based solutions to changes in climate are emphasized in the planning and implementation process of this innovative program. This presents an opportunity for conservation commissions to identify protection and restoration of wetlands, waters, and buffers including riparian corridors, as potential nature-based solutions eligible for support from the MVP Program. Additionally, creation of saltwater wetlands as “living shorelines” is an emerging approach to reducing greenhouse gas emissions.

4.2 Importance of Buffer Zones in a Changing Climate

Research over the past several years has led to greater understanding of the role of ecosystems, particularly wetlands and riparian corridors, in relation to climate change. Wetlands play a disproportionate role in the global carbon cycle and in provision of climate adaptation and resiliency ecosystem services yet are particularly vulnerable to impacts from climate change (Moomaw et al. 2018; Ramsar Convention on Wetlands 2018). Given the substantial scientific documentation of the importance of buffers in protecting the functional integrity of adjacent resource areas, buffers also make a significant contribution to protection of climate-related ecosystem services provided by resource areas. For the purposes of this Guidebook, **ecological resiliency** is defined as the capacity for an ecosystem to recover ecological functioning, complexity and biodiversity following a disruption, but does not necessarily include maintenance of species or species assemblages. Similarly, **human community resilience** refers to the capacity for a human community to recover structure and function, both physical and social, following a disruption, although recovery and reconstruction may involve reconfiguration to be more adaptive to future disruptions.

More specifically, wetlands (and thus, the buffers that protect them) play a significant role in the global carbon cycle (Chmura et al 2003; Bridgman et al 2006; Keddy 2010; Kirwan and Mudd 2012; Bridgman et al 2014; Neubauer and Megonigal 2015; Moomaw et al 2018), storing 20% - 30% of the world’s soil carbon, despite occupying a mere 5% - 8% of global land surface (Nahlik and Fennessy 2016). Nahlik and Fennessy (2016) provide a comprehensive assessment of carbon storage in United States wetlands, based on data from the [2011 National Wetland Condition Assessment](#), and state,

“Efforts to protect climate should address the role of wetlands as climate regulators and include measures for the conservation and sustainable management of their carbon stocks.”

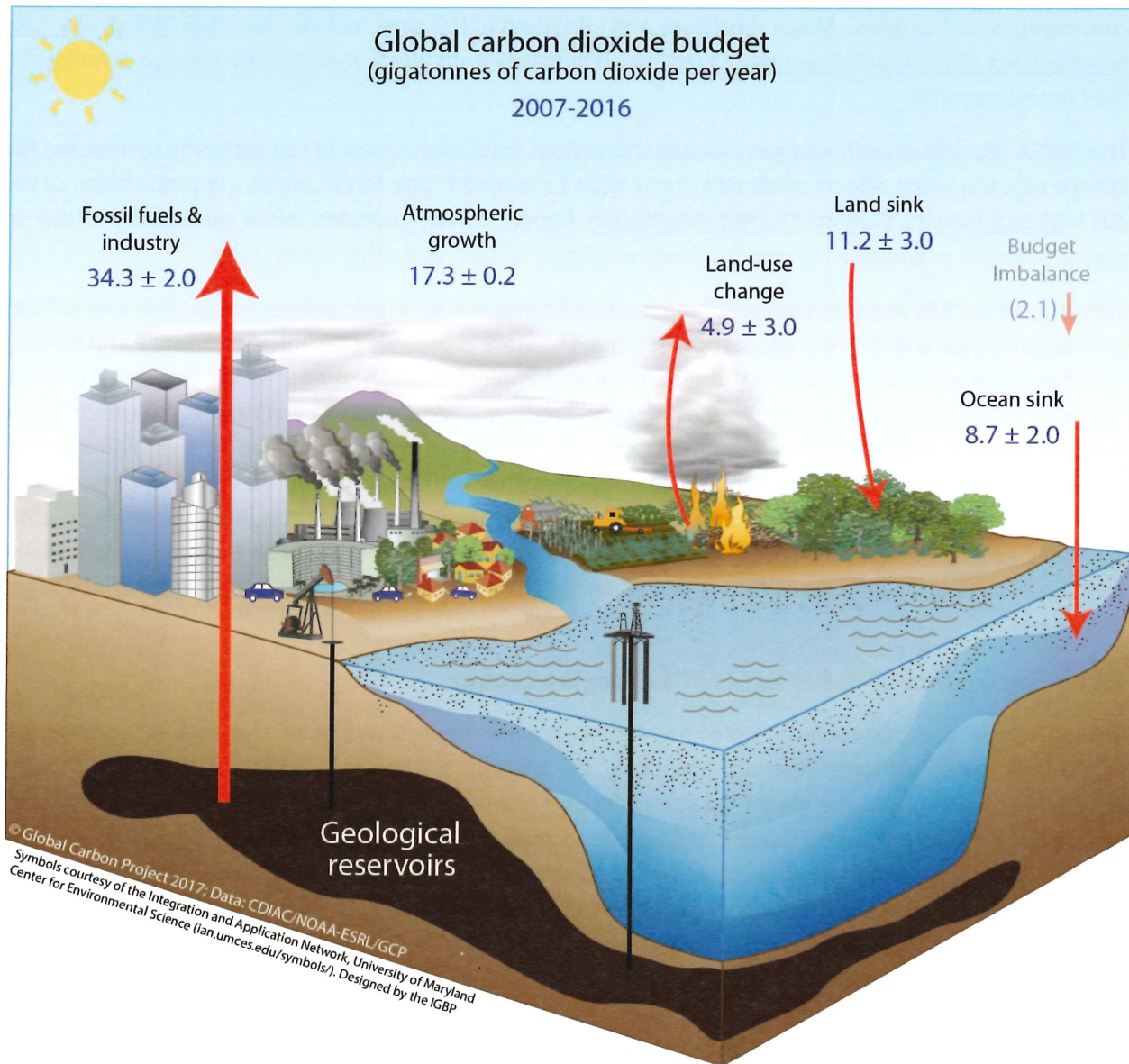


FIGURE 8: Global carbon dioxide budget. Reproduced from: *Global Carbon Budget 2017*, by Corinne Le Quéré et al (2017), *Earth System Science Data Discussions*.

Wetlands are recognized as providing important climate resiliency ecosystem services (Environmental Law Institute 2008; Keddy 2010; Junk et al 2013; ASWM 2015), yet they are particularly vulnerable to changes in climate (Erwin 2009; Kirwan and Mudd 2012; Junk et al 2013; Mitsch and Hernandez 2013; ASWM 2015). As discussed in previous chapters, buffer zones, including riparian corridors, play a role in protecting the functions and ecosystem services provided by wetlands, waterways, and water bodies, and therefore temper the impacts of stressors on wetlands and waters, which enhances the capacity for resource areas to adapt and respond with resilience to the challenges presented by climate change. Buffers can play a role in maintaining the microclimate of wetlands (and therefore of their associated waters) by helping to maintain temperature, humidity, wind patterns, and soil moisture (Adamus 2007).

As climate change impacts to wetlands, waters, buffers (including riparian corridors) and communities increase, effective responses will depend on adaptive policies and management strategies at all levels of

government. Local actions, particularly when coordinated regionally and with other levels of government, develop our capacity to prevent and/or reduce carbon emissions, adapt with resilience, and minimize negative impacts associated with climate change. The work of conservation commissions has never been more relevant to the sustainability of our future, and the significance of the role of buffers, including riparian corridors, is an important consideration.

4.2.1 Moderating the Global Carbon Cycle

Due to anaerobic (i.e. absence of oxygen) conditions in wetland soils, organic material (high in carbon) decomposes more slowly in wetlands than in uplands (see photo below). In wetlands, often there is a net accumulation of carbon on an annual basis, whereas in uplands, soil carbon oxidizes into the atmosphere more easily, and carbon accumulation is limited (Vepraskas and Craft 2015; Nahlik and Fennessy 2016; Ramsar Convention on Wetlands 2018). By protecting the functional integrity of wetlands, buffers contribute to the protection of carbon stored in wetlands.



Wetland soil high in organic material. Source: G. Davies, BSC Group, Inc.

Although freshwater wetlands emit methane (high in carbon) in addition to sequestering carbon dioxide (i.e. converting atmospheric carbon dioxide into plant material and then to soil organic matter), the storage of carbon exceeds the amount emitted, unless the freshwater wetland is disturbed or is relatively young (i.e. created / replicated wetlands). Newly created freshwater wetlands often emit more carbon than they store, until they reach a “switchover” point when they become net carbon sequesterers. The switchover point may take decades, hundreds, or thousands of years to occur (Neubauer 2014). Due to differing soil chemistry, saltwater wetlands emit minimal amounts of methane, even when newly created (Chmura et al 2003). Carbon stored in salt water wetlands is often referred to as Blue Carbon (see Figure 9).

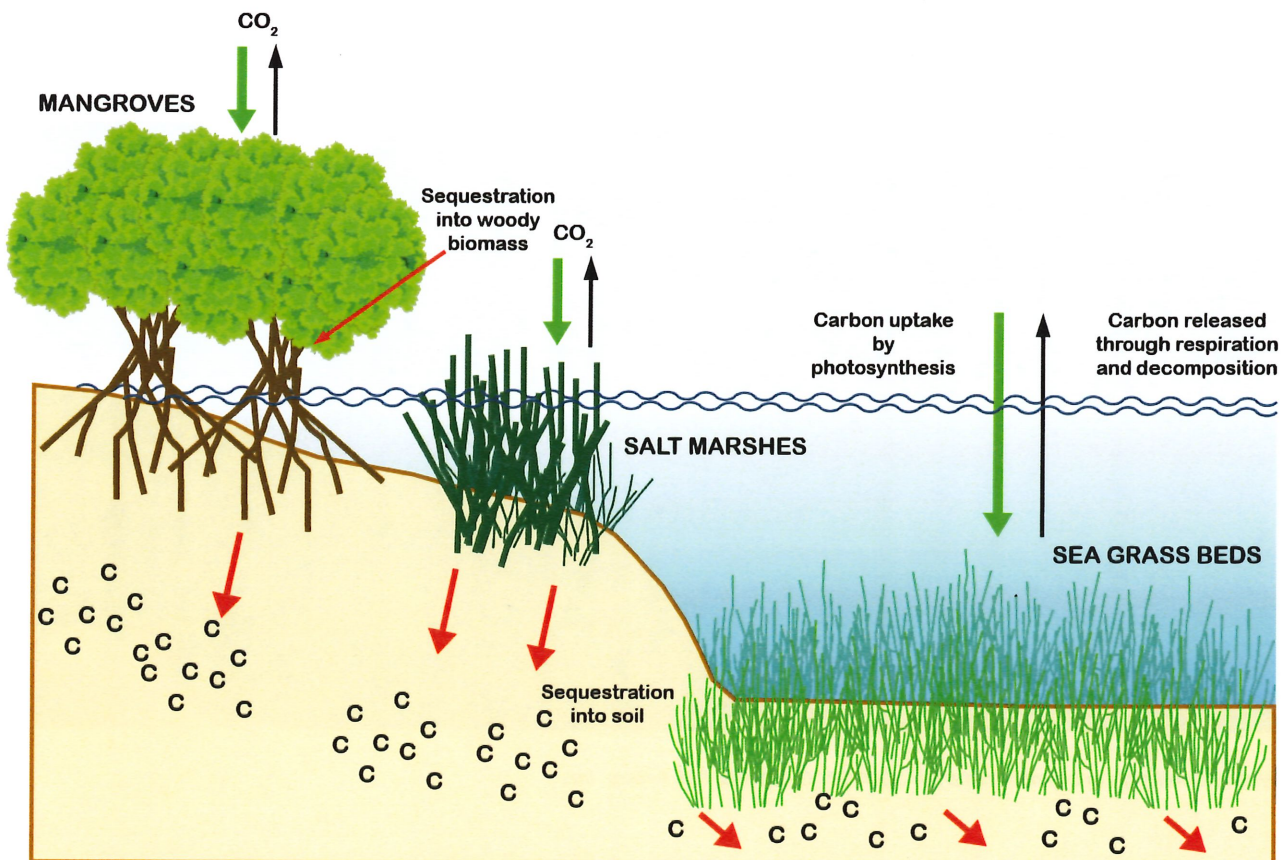


FIGURE 9: Coastal Blue Carbon. Mangrove forests, salt marshes and seagrass beds are highly efficient at removing more carbon dioxide from the atmosphere (green arrows) than is re-released (black arrows). Red arrows indicate substantial storage of carbon (grey C's) in soils for hundreds to thousands of years if left undisturbed. Modified from: [University of Maryland](#) based on Howard et al (2017).

However, disturbed saltwater wetlands are vulnerable to carbon loss in a variety of ways (Moomaw et al. 2018; Ramsar Convention on Wetlands 2018). For instance, saltwater wetland carbon stocks are vulnerable to degradation when the wetland is subjected to high levels of nitrogen runoff from adjacent areas (Moseman-Valtierra et al. 2016). Restoration of disturbed or drained freshwater and saltwater wetlands can lead to restoration of carbon storage functions, and creation of saltwater wetlands can lead to additional carbon storage (Erwin 2009; Badiou et al 2011, Moomaw et al 2018). The Waquoit Bay National Estuarine Research Reserve, in Falmouth and Mashpee, Massachusetts, provides leadership in this area with their [Bringing Wetlands to Market project](#).



Coastal wetlands, such as this salt marsh, excel at capturing carbon (carbon dioxide) from the atmosphere and storing large amounts in the soil each year. Photo was taken at Waquoit Bay National Estuarine Research Reserve in East Falmouth, Massachusetts. Source: A. Sutton-Grier, University of Maryland

A critical response to climate change is to protect the existing substantial stores of soil carbon (Bridgham et al 2006; Nahlik and Fennessy 2016) found in wetlands around the world, and to protect the biogeochemical processes that continue to pull carbon out of the atmosphere and sequester it into anaerobic wetland soils. Buffer zones, including riparian corridors, are important in protecting the chemical, physical and biological integrity of the adjacent wetland. For example, buffers that filter/remove influxes of nitrogen from upgradient developed and agricultural areas function to protect the ability of a salt marsh to store carbon (Moseman-Valtiera et al 2016). Likewise, Buffer Zones that prevent direct human impacts to fresh and saltwater wetlands protect wetland soil structure, vegetation, and biogeochemistry, all of which are involved in carbon sequestration and storage.

4.2.2 Climate Adaptation and Resiliency

Wetlands play a disproportionate role in the provision of ecological climate adaptation and resiliency services (Erwin 2009; ASWM 2015). Buffers and riparian corridors are critical in protecting the ability of wetlands, waterways and water bodies to provide climate adaptation and resiliency ecosystem services to surrounding communities, whether natural or human (Environmental Law Institute 2008). Anderson et al (2016a) state,

“Protecting wetlands and riparian corridors has been suggested as one of the single best actions in promoting resilience and in sustaining biodiversity (Naiman 1993, Fremier 2015).”

4.2.2.1 Enhancing Climate Resiliency - Moderating Hydrologic and Nitrogen Cycles

Water Quality

Wetlands improve water quality by filtering and transforming nutrients (such as nitrogen), pollutants and sediments, and buffers can help protect this function by offering additional filtering capacity and creating distance between upgradient activities and wetlands. Protection of water quality becomes more important to communities as our climate changes because water quality can be compromised during both high flows and low flows, and [climate models predict](#) increases in high precipitation events, flooding events, and droughts in Massachusetts. During flooding events, flood waters travel through uplands and can transport pollutants and toxins to wetlands and waters. Wetlands, along with their buffers, help remove these contaminants prior to entry into waterways and water bodies. During drought and low flows, toxins, pollutants and nutrients can become more concentrated in the limited water volumes of waterways and water bodies. Buffer zones, especially including riparian corridors, can provide filtering functions that limit pollution in adjacent aquatic resource areas, and can shade adjacent wetlands, waterways and water bodies, thus reducing losses of water volume due to evaporation and maintaining lower water temperatures. By maintaining lower water temperatures, buffers and riparian corridors reduce the risk of eutrophication. Eutrophication leads to deteriorated water quality.

Water Quantity - Storm Damage, Flooding and Drought Wetlands can absorb water like a sponge during high precipitation and flooding events and release the stored water during times of low flow and drought. They help to even out the peaks and troughs of the water cycle (Keddy 2010), and these ecosystem services become more valuable as our climate changes. Regulatory Buffer Zones and regulated Riverfront Areas can identify and/or protect additional space for wetlands to expand into, as greater water storage capacity is needed, and also prevent or minimize human impacts to areas that may temporarily shift delineation parameters (i.e. herbaceous vegetation shift from wetland to upland predominance) during droughts.

4.2.2.2 Enhancing Climate Resiliency - Facilitating Marsh Migration and Protecting Communities as Sea Level Rises and Severe Storms Increase

Protection of coastal wetlands increases the resiliency of nearby communities in the face of increased frequency of severe coastal storms and sea level rise. Coastal wetlands absorb coastal flooding and the energy of severe coastal storms, so that damages to infrastructure and communities are reduced. As an example, Narayan et al (2017) estimate that coastal wetlands prevented \$625 million in direct flood damage in the Northeastern United States during Hurricane Sandy. Buffer Zones help protect these important coastal resource areas. Research indicates that tidal marshes can keep up with sea level rise within certain thresholds, beyond which they are at risk of submergence (Morris et al 2002; Chmura et al 2003; Kirwan et al 2010). Modeling predicts that marshes are at risk of submergence and loss of productivity if sea levels rise by more than a meter by 2100 (Kirwan and Mudd 2012). Protected and regulated Buffer Zones in tidal areas experiencing sea level rise are particularly important in assisting tidal wetlands to adapt to climate change. They provide a naturally vegetated upgradient migration zone for tidal wetlands, assuming natural topography accommodates migration, thus assisting the wetland to avoid being caught in “coastal squeeze” (Nicholls 2004; Torio and Chmura 2013). In addition to predicted sea level rise elevations, coastal storm surge elevations should be considered when establishing tidal wetland migration buffer zones (Erwin 2009).



Source: MACC Fundamentals for Conservation Commissioners Training Program – Unit 104

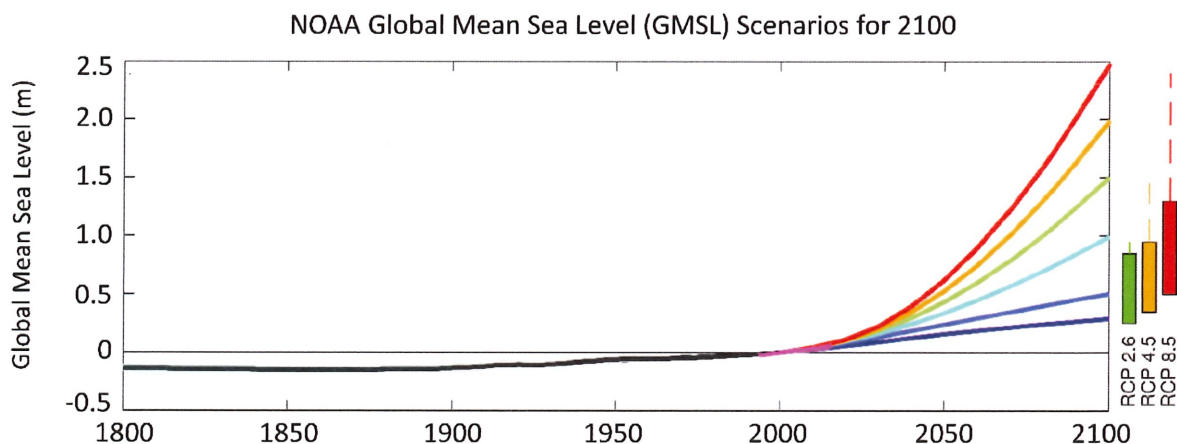


FIGURE 10: Historical and future changes in global mean sea level rise from the year 1800 to the year 2100. Colored lines indicate a range of IPCC climate scenarios based on differing concentrations of greenhouse gases in the atmosphere and the associated differing degrees of warming. The green line (RCP 2.6) predicts sea level rise (1.5 meters/4.92 feet) based on a model that assumes a significant reduction of greenhouse gas concentrations by the later part of the century. The yellow line (RCP 4.5) projects 2.0 meters/6.56 feet of sea level rise under a scenario that assumes moderate mitigation of greenhouse gas emissions. The highest projected sea level rise (RCP 8.5, red line) is 2.5 meters/8.20 feet, based on the assumption that greenhouse emissions are not significantly curbed (aka “business as usual”, continued intensive use of fossil fuels)). Reproduced from: NOAA (2017).

4.2.2.3 Enhancing Climate Resiliency - Providing Localized Cooling and Maintaining Microclimate Conditions

Wetlands, waterways, and water bodies provide localized cooling on the landscape, which benefits both human communities and wildlife, fish and shellfish. Vegetated areas in general are cooler than developed land, but wetlands, waterways, and water bodies have the added benefit of the heat-absorbing qualities of water. Anderson et al (2016a) identify landscapes with a high density of wetlands as being more ecologically climate resilient than other landscapes because a mosaic of wetlands creates temperature and humidity gradients on the landscape, in much the same way that changes in elevation do. Cooler wet areas then serve as local refugia for wildlife, fish, shellfish and humans when high heat events occur. Wetland mosaics are particularly important in areas without a great deal of topographic variability. Buffers, particularly those that are forested and shrub-dominated, provide shade to adjacent wetlands, waterways and water bodies, and thus help protect the cooler temperatures and natural microclimates (e.g. temperature, humidity, wind patterns, soil moisture) in these areas (Adamus 2007; Environmental Law Institute 2008; Hruby 2013).

4.2.2.4 Enhancing Climate Resiliency - Wildlife Habitat: Landscape Connectivity

As mentioned above, buffers, including riparian corridors, can be significant in maintaining resource area microclimates (Adamus 2007), and providing areas of localized cooling on the landscape, which can be essential to wildlife, fish, and shellfish. As our climate changes, the importance of wetland buffer zones for wildlife, fish and shellfish increases, because in addition to traditional habitat requirements, species increasingly require naturally vegetated corridors that allow them to migrate northward and/or to higher elevations in response to a warming world, and buffers and riparian corridors can help to increase connectivity at the landscape scale (Lawler 2009; Fremier et al 2015; Anderson et al 2016b). Timpane-Padgham et al (2017), note that connectivity supports resiliency by allowing the flow of biological and

non-biological components of ecosystems, including genetic material, individuals, populations, water, food exchanges, and by allowing access to diverse habitats that meet a variety of life stage requirements. As a result, species, habitats and ecosystems are better able to self-organize and recover when challenged by climatic disruptions and changes.

The additional width and habitat diversity provided by regulatory upland Buffer Zones and Riverfront Areas allows a broader range of species and a greater number of individuals to utilize wetlands, waterways, and riparian corridors as travel corridors. Given the anticipated impacts to wildlife habitat, fisheries and shellfisheries as our climate changes, conservation commissions may wish to review the [*Climate Change and Massachusetts Fish and Wildlife Volume 3, Habitat Management*](#) report (Manomet Center for Conservation Services & Massachusetts Division of Fisheries and Wildlife, 2010).

4.3 Vulnerability of Wetlands to Climate Change

Wetlands exist in the zone between truly aquatic ecosystems and truly terrestrial ecosystems. Often, this transitional zone has limited elevational ranges, between the “too wet” and the “too dry”, and thus is particularly vulnerable to changes in the hydrologic cycle (Erwin 2009). Additionally, wetlands often exist in low-lying areas on the landscape and thus experience both the local impacts of climate change and those that accumulate or intensify in lower regions of a watershed or landscape (Finlayson et al 2017). Climate models predict more hydrologic extremes in both directions, thus increasing the likelihood that wetlands will be converted, at least temporarily, to areas with deeper flooding, or to drier areas with aerobic soils and low soil moisture. When this happens, temporary or more permanent shifts in vegetation can occur. Soil biogeochemistry can change (Erwin 2009). As climate changes, we may see shifts in species and species assemblages (both plant and animal) (Lawler 2009). More southern species, and opportunistic, easily adaptable invasive species, may replace indigenous species. Pests and diseases may increase with warming temperatures, putting further stress on indigenous species. Relationships between species may be disrupted (such as flowering timed according to spring temperatures whereas the arrival of pollinators is timed according to changes in daylight). Severe storm events can disrupt ecological structure, which may not easily rebound to the pre-storm condition. Climate change acts synergistically with many existing ecological stressors, such as urbanization, invasive species, hydrologic alterations, pollution, and changes in land use. The sum of these pressures can lead to ecosystem shifts and/or disassembly (Lawler 2009; Tate and Battaglia 2013), such as is currently most visible in arctic ecosystems, where temperature increases are the most severe.

As noted in preceding sections, buffer zones, including riparian corridors, function to protect the ecological functions and characteristics of wetlands, waterways and water bodies, and in doing so, they allow these important resource areas to be more resilient to climate change and to continue to offer substantial climate resiliency ecosystem services to human communities, wildlife, and adjacent upland ecosystems (Environmental Law Institute 2008). Increasing the size of buffers has been recommended as a strategy to enhance climate resiliency of adjacent resource areas (Lawler 2009).

4.4 Wildlife Habitat: Protection from Human Disturbance (Noise and Artificial Light)

Vegetated buffers, including riparian corridors, provide physical barriers between wetlands and human impacts. Vegetated buffers restrict easy access to wetlands, waterways, and water bodies, and therefore limit incursion by humans and non-native species, contribute to avoiding soil compaction (from off-road vehicles for example), reduce disturbance of wildlife, (Adamus 2007) and deter direct fill and impact activities such as disturbance of vegetation and dumping. Buffer vegetation also reduces noise from

humans and machinery, as well as artificial light. One study found that a thirty-foot vegetated barrier reduces highway noise by two to three decibels (Harris and Cohn 1985). Noise is abated through a process of excess attenuation, or the scattering, refraction and absorption of sound waves. Density, height, length and width of tree belts are the most important factors in reducing noise (Cook and Van Haverbeke 1971). Noise pollution has far-reaching consequences for wildlife, particularly birds. Chronic exposure to noise causes changes in reproductive success, foraging and anti-predator behavior and density and community structure (Barber et al 2010). In avian communities, noise pollution alters species interactions and changes community composition (Francis et al 2009).

4.5 Recreational, Educational, Spiritual and Aesthetic Interests

Wetlands provide many recreational, educational, spiritual and aesthetic services for society. Naturalists, hunters, fishermen, canoeists, hikers, and families use wetlands to connect to nature and find inspiration. Several religions ascribe spiritual value to wetland ecosystems. In the United States, 35-40 million people spend a total of \$24-37 billion on recreational fishing in inland and saltwater ecosystems (Millennium Ecosystem Assessment 2005). Wetlands can also be used as a hands-on, ecological learning classroom for students of all ages, promoting wetland conservation and sustainable living across generations. Learning activities in wetlands include citizen-science projects, species identification, local school field trips, and wetland management workshops for members of the community (Hails 2016), as well as for professionals.

4.6 Economic Values

Economic valuations of wetlands and buffer zones, including riparian corridors, can be useful in protecting wetland resources. Placing monetary values on natural resources makes it easier to understand the benefits of wetlands and associated buffers, and support local measures aimed at protecting them. The Reference section provides a list of economic valuation studies that pertain to wetland resource areas and associated buffers.

Environmental resources are assigned value based on a concept known as ecosystem services. In short, ecosystem services are the benefits that society obtains from nature. The Interests of the Act are ecosystem services and are protected because of their value to society. Ecosystems services can be grouped into four categories (Millennium Ecosystem Assessment 2005; Ramsar Convention on Wetlands 2018):

- 1) provisioning services such as providing food and water;
- 2) regulating services such as climate regulation and flood control;
- 3) cultural services such as recreation and spirituality, and
- 4) supporting services that maintain life on Earth, such as nutrient cycling and soil formation.

Costanza et al (2014) provide discussion of ecosystem services and their valuation. Valuation is about assessing trade-offs toward achieving a goal (Farber et al 2002). All decisions that involve trade-offs involve valuation, either implicitly or explicitly (Costanza et al 2011). Ecosystem services are defined as the benefits people derive from ecosystems – the support of sustainable human well-being that ecosystems provide (Costanza et al 1997; Millennium Ecosystem Assessment 2005). The value of ecosystem services is therefore the relative contribution of ecosystems to the goal.

Probably the most important contribution of the widespread recognition of ecosystem services is that it reframes the relationship between humans and the rest of nature. A better understanding of the role of ecosystem services emphasizes our natural assets as critical components of inclusive wealth, well-being, and sustainability. Sustaining and enhancing human well-being requires a balance of all our assets – individual people, society, the built economy, and ecosystems. This reframing of the way we look at “nature” is essential to solving the problem of how to build a sustainable and desirable future for humanity.

Wetlands provide a variety of ecosystems services across the four categories of provision, regulation, cultural and supporting services, as indicated in Table 4 (Mitsch et al 2015; Millennium Ecosystem Assessment 2005; Ramsar Convention on Wetlands 2018). Many of these services go beyond the Interests of the Act, or how we have interpreted the Interests in the past. These include peat and timber production, carbon sequestration and storage, climate adaptation and resiliency, nature education, hydric soil development, recreation, pollination, and aesthetics, among others (Table 4). In general, the ecosystem service value of wetlands appears to increase with additional human stress (Ghermandi et al 2010).

Table 4: Eight Interests of the Massachusetts Wetlands Protection Act and Additional Ecosystem Services Not Covered by the Interests. Adapted from Mitsch et al. 2015 and Clarkson et al. 2013.

EIGHT INTERESTS OF THE WPA
Protection of public and private water supply
Protection of groundwater supply
Flood control
Storm damage protection
Prevention of pollution
Protection of land containing shellfish
Protection of fisheries habitat
Protection of wildlife habitat
ADDITIONAL ECOSYSTEM SERVICES
Peat production
Animal harvesting and fur collection
Timber production
Food production
Carbon sequestration and storage
Climate adaptation and resiliency
Aesthetics

ADDITIONAL ECOSYSTEM SERVICES
Recreation
Nature education
Ecotourism
Bird watching
Hydric soil development
Primary productivity
Cultural and spiritual connection
Nutrient cycling
Genetic resources and seed banks
Artistic inspiration
Pollination
Medicinal and ornamental resources

The monetary value of wetland ecosystem services is difficult to estimate and varies among studies (Woodward and Wui 2001), yet these estimates help society gauge the importance of wetlands protection. Valuations of wetland ecosystem services are often broken down by ecosystem type (e.g. estuarine, forested) and service category type (e.g. provisional). Total global ecosystem services for estuaries, inland floodplains and swamps, and tidal marshes and mangroves are estimated to be \$28,916 per hectare per year, \$25,681 per hectare per year and \$193,843 per hectare per year, respectively (Costanza et al 2014). In agricultural landscapes, wetlands provide many regulatory services, specifically flood control, water supply and nutrient cycling. The total value of wetland regulating services in agricultural landscapes in the United States is an estimated \$1.809 billion per year (Brander et al 2013).

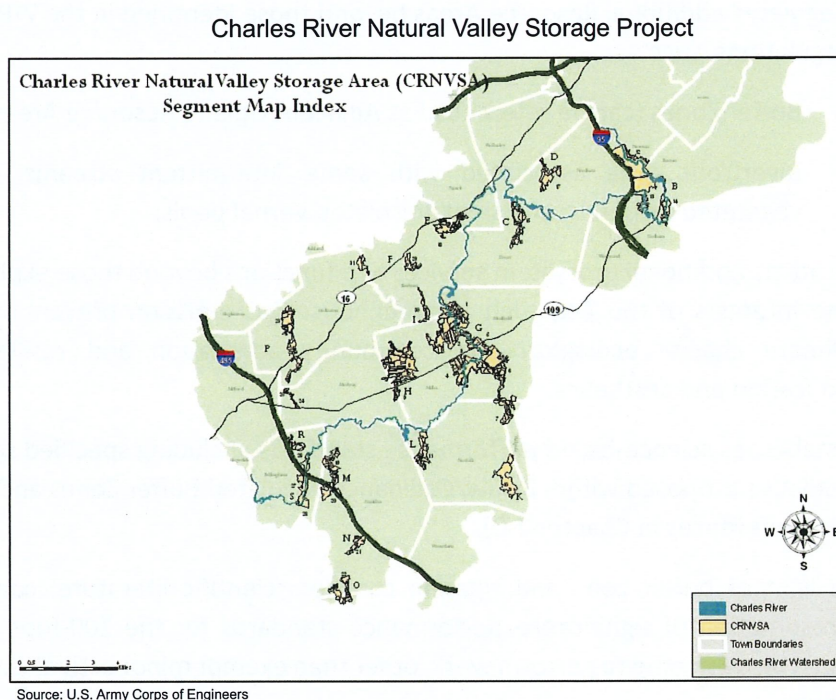
Costanza et al (2008) estimate that coastal wetlands in the U.S. provide \$23.2 billion per year in storm protection services, and Narayan et al (2017) estimate that coastal wetlands prevented \$625 million in direct flood damage in the Northeastern United States during Hurricane Sandy. Globally, the combined average value of ecosystem services for coastal wetlands is an estimated \$193,845 per hectare per year. For inland wetlands, global ecosystem services are an estimated \$25,682 per hectare per year (de Groot et al 2012).

Additionally, ecological restoration, dubbed the “restoration economy” is estimated to provide \$24.86 billion and 221,000 jobs to the US economy on an annual basis (BenDor et al 2015), and wetland, buffer and riparian zone restoration are included in this total.

The ecosystem services provided by wetlands are a source of considerable financial value for society. By maintaining the ecological functions of wetlands and protecting them from human impact, buffers inherently contribute to the financial benefits derived from wetland ecosystem services.

The Charles River Natural Valley Storage Area is an example of a project that demonstrates how an understanding of the economic value of wetlands and their ecosystem services facilitated a choice to provide flood storage through the conservation of wetlands. This smart choice avoided the expenditure of more than triple the wetland land purchase cost to construct a traditional flood control structure.

ECONOMIC VALUATION OF WETLANDS CASE STUDY: CHARLES RIVER NATURAL VALLEY STORAGE PROJECT



In 1974, Congress authorized the purchase and permanent protection of 17 scattered wetlands in the middle and upper parts of the Charles River Watershed, with a total acquisition cost of \$8,300,000 for 8,103 acres, instead of constructing a \$30 million flood control structure. The wetlands were anticipated to prevent flood damages worth an estimated \$6 million. In addition to preventing flood damages, all other ecosystem services provided by the wetlands were protected, thus adding to the value of the conservation purchase.

5.0 WRITING WETLAND BYLAWS AND ORDINANCES: DEVELOPING SCIENCE AND PERFORMANCE-BASED STANDARDS FOR BUFFER ZONES

Municipalities may wish to develop local Bylaws/Ordinances and include science-based performance standards that protect Buffer Zone and Riverfront Area contributions to Interests of the Act and other functions and ecosystem services, such as those discussed in preceding Chapters. In doing so, it is recommended that conservation commissions evaluate the current science and then determine appropriate responses for their own municipality. Given the Buffer Zone science referenced throughout this Guidebook, municipalities may wish to consider drafting a Bylaw or Ordinance that:

- Regulates additional Resource Areas beyond those identified in the WPA and associated regulations, such as,
 - Buffer Zones (can be referenced as Adjacent Upland Resource Areas);
 - Riverfront Area associated with some intermittent streams, smaller isolated vegetated wetlands, and smaller isolated vernal pools;
- Protects additional ecosystem services and functions beyond those explicitly identified in the Interests of the Act, such as greenhouse gas emission prevention and reduction, climate change ecological and community adaptation and resilience, recreation, education and aesthetics.
- Establishes science-based performance standards, including specified setback widths for activities proposed within Bylaw/Ordinance-regulated Buffer Zones and Riverfront Areas (See references in Chapter 2.0).
- In light of buffer zone and riparian corridor scientific literature, consider identifying presumption of significance performance standards for the 100-foot Buffer Zone that must be overcome to perform work, other than exempt minor activities, within the Buffer Zone.
 - Include performance standards based on the ecosystem services/functions being protected, site conditions, nature of proposed work and other factors enumerated in this Guidebook.
 - Include a means for overcoming the presumption of significance based on site conditions and nature of proposed work.
 - Include a waiver or variance process based on site conditions, nature of proposed work, and hardship considerations. In addition to standard waiver/variance provisions such as ensuring an overriding public benefit and avoiding an unconstitutional taking, waiver/variance processes should identify standards for obtaining the waiver/variance, such as:
 - Alternatives Analysis has been provided, documenting that impacts/alterations have been avoided to the greatest extent practicable, with remaining alterations

minimized to the greatest extent practicable, and finally, that for any unavoidable impacts, appropriate mitigation has been provided.

- Buffer Zone and/or adjacent Resource Area are disturbed or degraded.
- Proposed work is minimal or a minimum size (e.g. single-family house, subdivisions smaller than a specific number of lots, projects that meet a certain setback).
- Allows for work that at times may unavoidably be in or near wetlands, such as driveway or road crossings or water dependent projects.
- Proposed mitigation is significant and results in net ecological gain.

[The MACC Model Bylaw/Ordinance](#) and the [MACC Handbook](#) are important resources when developing or updating a local Bylaw or Ordinance. These resources address development of a local Bylaw or Ordinance comprehensively, whereas this Guidebook is limited to considerations pertaining to Buffer Zones and the aspects of Riverfront Areas that provide buffering to adjacent Resource Areas. Other useful resources that conservation commissions may wish to refer to while developing a Bylaw or Ordinance include:

- Planner's Guide to Wetland Buffers for Local Governments (2008), Environmental Law Institute;
- Model Ordinances for Regulating Wetlands; Riparian Habitats; Stream Buffers (Kusler 2009), Association of State Wetland Managers; and
- Update on Wetland Buffers: The State of the Science, Final Report (Hruby 2013), State of Washington Department of Ecology.

Local Bylaws/Ordinances typically incorporate language relevant to Buffer Zones and the buffering capacity of Riverfront Areas as noted in the following subsections.

5.1 Bylaw/Ordinance - Statement of Purpose

Municipalities can identify zones of protection for "Adjacent Upland Resource Areas" (i.e. Buffer Zones), which are adjacent to Resource Areas, as one of the purposes of the Bylaw/Ordinance, based on Buffer Zones being significant to protecting Resource Area ecosystem services and functions. Regulation of local Buffer Zones and Riverfront Areas must be tied to the Interests identified in the Bylaw or Ordinance and can include additional, or previously unrecognized, ecosystem services and functions that the municipality wishes to protect, such as:

- Greenhouse gas emission prevention and reduction by recognizing the importance of maintaining undisturbed organic soil and vegetation in wetlands.
- Climate adaptation and resiliency ecosystem services by recognizing the role wetlands and buffer zones, including riparian areas, play in storm damage prevention, salt marsh migration, water quality, water supply, provision of localized cooling, and protection of biodiversity, wildlife habitat, fisheries, and shellfisheries.
- Recreation, education and aesthetics.

5.2 Bylaw/Ordinance - Statement of Jurisdiction

Municipalities can claim jurisdiction over:

- The 100-foot Buffer Zone (or larger areas) as a Resource Area (Adjacent Upland Resource Area) in and of itself, rather than simply as a regulated area without performance standards.
- The 100-foot Buffer Zones (or larger areas) adjacent to any freshwater or coastal wetlands of any size and both intermittent or perennial features, including: marshes; wet meadows; bogs; fens; swamps; vernal pools; springs; banks; intermittent land under waterways, streams, brooks, and creeks; perennial rivers, streams, brooks and creeks and the adjacent 200-foot Riverfront Area; land under water bodies; reservoirs; lakes; ponds; beaches; dunes; estuaries; and the ocean.
- Lands subject to flooding or inundation by groundwater or surface water; lands subject to tidal action, coastal storm flowage, or flooding.
- All the above can be protected whether or not they border surface waters.
- In some communities, the 200-foot Riverfront Area may be extended to intermittent streams, brooks, and ponds.
- In some communities, the 100-foot Buffer Zones to catch basins tributary to wetland Resource Areas are protected.

Under the WPA, Buffer Zones are assigned to wetlands and non-flowing water bodies, riverfronts are assigned to perennially flowing waterways, and areas of flooding have no Buffer Zone.

5.3 Bylaw/Ordinance - Statement of Presumptions of Significance

The statement of presumption of significance outlines the ecosystem services/functions/Interests that a Resource Area (at the local level, can include Buffer Zones) is presumed to be significant to. Buffer Zones and Riverfront Areas can be presumed to be significant to the protection of the ecosystem services, functions and Interests of the Act where science supports such a presumption, including ecosystem services and functions that are not explicitly named in the eight Interests of the Act. The extensive information provided in Chapters 2.0 and 4.0 provides documentation that conservation commissions can reference when formulating presumptions of significance for Buffer Zones and for the buffering services that Riverfront Areas provide to adjacent Resource Areas.

5.4 Bylaw/Ordinance - Statement of Burden of Proof Requirements for Applicant

The MACC model Wetlands Bylaw/Ordinance provides a standard Burden of Proof statement as noted below. The importance of the statement of Burden of Proof cannot be over-stated, as it makes clear that it is the Applicant's responsibility to disprove presumptions of significance, thereby relieving the Conservation Commission from having to repeatedly re-prove the significance of regulated Resource Areas (including Buffer Zones/Adjacent Upland Resource Areas if designated) and the Conservation Commission's jurisdiction over these areas.

The applicant for a permit shall have the burden of proving by a preponderance of the credible evidence that the work proposed in the permit application will not have unacceptable significant or cumulative effect upon the resource area values [i.e. ecosystem services and functions] protected by this bylaw. Failure to provide adequate evidence to the Conservation Commission supporting this burden shall be sufficient cause for the Commission to deny a permit or grant a permit with conditions.

5.5 Bylaw/Ordinance – Findings and Decisions

Conservation commissions can reference studies in Chapters 2.0 and 4.0 when evaluating Buffer Zone and Riverfront Area projects, and thus can tailor their Findings and Decisions to sites and projects on a case-by-case basis, based on identifying the most appropriate study for the specific site and project.

REFERENCES

NOTE: Following the general references section, a list of references on the economic valuation of wetlands is provided separately (see below).

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APPENDIX A – DEFINITIONS, ACRONYMS AND ABBREVIATIONS

DEFINITIONS

anthropogenic	<p>“Made by people or resulting from human activities. Usually used in the context of emissions that are produced as a result of human activities”</p> <p>https://19january2017snapshot.epa.gov/climatechange/glossary-climate-change-terms_.html</p>
biomass carbon	<p>“Materials that are biological in origin, including organic material (both living and dead) from above and below ground, for example, trees, crops, grasses, tree litter, roots, and animals and animal waste”.</p> <p>https://19january2017snapshot.epa.gov/climatechange/glossary-climate-change-terms_.html and http://unfccc.int/resource/cd_roms/na1/ghg_inventories/english/8_glossary/Glossary.htm</p>
Bordering Vegetated Wetlands	<p>“Freshwater wetlands which border on creeks, rivers, streams, ponds and lakes...areas where the soils are saturated and/or inundated such that they support a predominance of wetland indicator plants.” (MA WPA regulations 310 CMR 10.55(2)(a)).</p>
Buffer Zone	<p>“...area of land extending 100 feet horizontally outward from the boundary of any area specified in 310 CMR 10.02(1)(a)”. (MA WPA regulations 310 CMR 10.04, and Buffer Zone Guidebook Section 1.3.1).</p>
buffers and buffer zones (not capitalized)	<p>“The area surrounding a wetland that helps maintain the wetland's functional integrity and furnishes protection against the impacts to the wetland from activities in adjacent upland areas” (Kusler/ASWM 2009). See Buffer Zone Guidebook Sections 1.2 and 1.3.3.</p>
channelization	<p>“Channelization and channel modification describe river and stream channel engineering undertaken for flood control, navigation, drainage improvement, and reduction of channel migration potential. Activities that fall into this category include straightening, widening, deepening, or relocating existing stream channels and clearing or snagging operations. These forms of hydromodification typically result in more uniform channel cross-sections, steeper stream gradients, and reduced average pool depths. Channelization and channel modification also refer to the excavation of borrow pits, canals, underwater mining, or other practices that</p>

	<p>change the depth, width, or location of waterways, or embayments within waterways. Channelization and channel modification activities can play a critical role in nonpoint source pollution by increasing the downstream delivery of pollutants and sediment that enter the water. Some channelization and channel modification activities can also cause higher flows, which increase the risk of downstream flooding.” https://www.epa.gov/sites/production/files/2015-09/documents/chapter_3_channelization_web.pdf</p>
climate adaptation	<p>“Adjustment or preparation of natural or human systems to a new or changing environment which moderates harm or exploits beneficial opportunities”. https://19january2017snapshot.epa.gov/climatechange/glossary-climate-change-terms.html</p>
denitrification	<p>“Denitrification is the microbial process of reducing nitrate and nitrite to gaseous forms of nitrogen, principally nitrous oxide (N₂O) and nitrogen (N₂).” https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/denitrification</p>
ecosystem	<p>“A dynamic complex of plant, animal and micro-organism communities and their nonliving environment interacting as a functional unit” (Convention on Biological Diversity, United Nations 1992: Article 2)</p>
ecosystem services	<p>“Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits.” (Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: Wetlands and Water Synthesis) http://biodiversitya-z.org/content/ecosystem-services</p> <p>“Ecosystem services, outputs, conditions, or processes of natural systems that directly or indirectly benefit humans or <u>enhance</u> social welfare. Ecosystem services can benefit people in many ways, either directly or as inputs into the production of other goods and services. For example, the <u>pollination</u> of crops provided by <u>bees</u> and other organisms contributes to <u>food</u> production and is thus considered an ecosystem service. Another example is the attenuation of flooding in residential areas provided by riparian buffers and <u>wetlands</u>”. https://www.britannica.com/science/ecosystem-services</p> <p>“Ecosystem services are commonly defined as the benefits people obtain from ecosystems. Ecosystem services include basic services - provisioning services like the delivery of food, fresh water, wood and fiber, and medicine - and services that are less tangible and harder to measure but equally critical: regulating services like</p>

	<p>carbon sequestration, erosion control, and pollination; cultural services like recreation, ecotourism, and educational and spiritual values; and supporting services like nutrient cycling, soil formation, and primary productivity.” https://www.fs.fed.us/ecosystemservices/About_ES/faq.shtml</p>
ecotone	<p>Transitional zone between two ecological systems. https://www.esa.org/esablog/about/ecotone-explained/</p> <p>“...SCOPE/ MAB working group (Holland (1988): “zone of transition between adjacent ecological systems, having a set of characteristics uniquely defined by space and time scales and by the strength of the interactions between adjacent ecological systems.” In this definition the term “ecological system” includes such commonly described hierarchical entities such as demes, populations, communities, ecosystems, landscapes, and biomes (Gosz 1991; Holland 1988). In this definition ecotones are interpreted as biological boundaries of various scales. It is important to remember that boundaries are identifiable and meaningful only relative to specific questions and points of reference. An ecotone at one spatial scale may be seen as a collection of patches on a finer scale (Gosz 1991).” https://www.fs.fed.us/rm/pubs/rmrs_p011/rmrs_p011_049_055.pdf</p>
ephemeral pools (also see vernal pools)	<p>Pools that normally hold water for only part of the year. Typically, in Massachusetts, they, “...fill with water in the autumn or winter due to rainfall and rising groundwater and remain ponded through the spring and into summer.” https://www.mass.gov/vernal-pools</p>
ephemeral streams (also see intermittent streams)	<p>Streams which flow only after precipitation events. Rainfall runoff is primary source of water. https://archive.epa.gov/water/archive/web/html/streams.html#types</p> <p>“Ephemeral: A stream that has flowing water only during or for a short duration after precipitation events in a typical year. In many states, this term refers to streambeds that are located above the water table year-round and streams where groundwater is not a source of water for the stream.” https://www.aswm.org/stream_mitigation/streams_in_the_us.pdf</p>
erosion controls	<p>Measures taken to prevent or control erosion of soil that would otherwise result from exposure of soil to wind and flowing or falling water.</p>

Eutrophication	<p>“Eutrophication occurs when a body of water receives an excessive nutrient load, particularly phosphorus and nitrogen. This often results in an overgrowth of algae. As the algae die and decompose, oxygen is depleted from the water, and this lack of oxygen in the water causes the death of aquatic animals, like fish.”</p> <p>https://www.usgs.gov/centers/wetland-and-aquatic-research-center-warc/science-topics/eutrophication</p>
groundwater	<p>“groundwater--(1) water that flows or seeps downward and saturates soil or rock, supplying springs and wells. The upper surface of the saturated zone is called the water table. (2) Water stored underground in rock crevices and in the pores of geologic materials that make up the Earth's crust.”</p> <p>https://water.usgs.gov/edu/dictionary.html#G</p>
Inland Bank	See MA WPA regulations 310 CMR 10.54(2).
Interests of the Act	The eight Interests or functions that wetland Resource Areas provide, listed at MA WPA regulations 310 CMR 10.01(2).
intermittent streams (also see ephemeral streams)	<p>“Intermittent stream - A stream that flows only when it receives water from rainfall runoff or springs, or from some surface source such as melting snow.” US Geological Survey, National Water Quality Assessment (NWQA) Project.</p> <p>https://water.usgs.gov/nawqa/glos.html</p> <p>“Stream means a body of running water, including brooks and creeks, which moves in a definite channel in the ground due to a hydraulic gradient, and which flows within, into or out of an Area Subject to Protection under M.G.L. c. 131, § 40. A portion of a stream may flow through a culvert or beneath a bridge. Such a body of running water which does not flow throughout the year (i.e., which is intermittent) is a stream except for that portion upgradient of all bogs, swamps, wet meadows and marshes”. Wetlands Protection Act regulations, 310 CMR 10.04.</p> <p>“Intermittent: A stream that has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from precipitation is a supplemental source of water for stream flow.”</p> <p>https://www.aswm.org/stream_mitigation/streams_in_the_us.pdf</p>

living filters	Naturally vegetated "...protective areas between a waterbody and human activity, such as development and agriculture." (Massachusetts Buffer Manual (2003), Buffer Zone Guidebook Section 1.3.3).
Mean Annual High Water line	<p>"Mean Annual High Water Line of a river is the line that is apparent from visible markings or changes in the character of soils or vegetation due to the prolonged presence of water and that distinguishes between predominantly aquatic and predominantly terrestrial land. Field indicators of bankfull conditions shall be used to determine the mean annual high water line. Bankfull field indicators include but are not limited to: changes in slope, changes in vegetation, stain lines, top of pointbars, changes in bank materials, or bank undercuts.</p> <ul style="list-style-type: none"> a. In most rivers, the first observable break in slope is coincident with bankfull conditions and the mean annual high water line. b. In some river reaches, the mean annual high water line is represented by bankfull field indicators that occur above the first observable break in slope, or if no observable break in slope exists, by other bankfull field indicators. These river reaches are characterized by at least two of the following features: low gradient, meanders, oxbows, histosols, a low-flow channel, or poorly-defined or nonexistent banks. c. In tidal rivers, the mean annual high water line is coincident with the mean high water line determined under 310 CMR 10.23." MA WPA Regulations 310 CMR 10.58(2).
mitigate	<p>"Mitigation means rectifying an adverse impact by repairing, rehabilitating or restoring the affected resource area or compensating for an adverse impact by enhancing or providing replacement resource areas." MA Wetlands Protection Act, 310 CMR 10.04.</p> <p>"Mitigation refers to actions that reduce the human contribution to the planetary greenhouse effect. Mitigation actions include lowering emissions of greenhouse gases like carbon dioxide and methane, and particles like black carbon (soot) that have a warming effect." https://nca2014.globalchange.gov/report/response-strategies/mitigation#intro-section-2</p> <p>"Climate mitigation is any action taken to permanently eliminate or reduce the long-term risk and hazards of climate change to human life, property." http://www.global-greenhouse-warming.com/climate-mitigation-and-adaptation.html</p> <p>"Mitigation - A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks." https://19january2017snapshot.epa.gov/climatechange/glossary-climate-change-terms .html This document also references another sub-reference:</p>

	https://archive.ipcc.ch/pdf/glossary/tar-ipcc-terms-en.pdf
perennial streams	<p>See MA WPA regulations 310 CMR 10.58 for regulatory definition, and Appendix E.</p> <p>“Perennial: A stream that has flowing water year-round during a typical year. The water table is located above the streambed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from precipitation is a supplemental source of water for stream flow.”</p> <p>https://www.aswm.org/stream_mitigation/streams_in_the_us.pdf</p>
Performance Standards	Standards that applicants are normally required to meet in order to conduct a permitted activity.
resilience-resiliency	<p>“The capacity of a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption” (National Oceanic and Atmospheric Administration (NOAA) U.S. Climate Resilience Toolkit Glossary https://toolkit.climate.gov/content/glossary).</p> <p>“Resilience - A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.”</p> <p>https://19january2017snapshot.epa.gov/climatechange/glossary-climate-change-terms_.html</p> <p>“...the ability for an ecosystem to restore healthy ecological function, complexity, diversity and processes following a disruption, although specific species and species assemblages may change.” (Moomaw et al 2018)</p>
Resource Area	“Resource Area means any of the areas specified in 310 CMR 10.25 through 10.35 and 10.54 through 10.58. It is used synonymously with Area Subject to Protection under M.G.L. c. 131, § 40, each one of which is enumerated in 310 CMR 10.02(1).” Wetlands Protection Act regulations 310 CMR 10.04.
resource area (not capitalized)	Refers more generally to natural ecosystems and ecological resources. (Buffer Zone Guidebook Section 1.2).
riparian zones	“Riparian Zone: The riparian zone is defined as the transitional area between terrestrial and aquatic ecosystems. These areas are characterized by connected biophysical conditions that connect and link surface and subsurface hydrology with water ways and their adjacent uplands. Riparian areas are adjacent to perennial,

	intermittent, and ephemeral streams, lakes and estuarine marine shorelines.” https://www.aswm.org/stream_mitigation/streams_in_the_us.pdf
Riparian Area	“Vegetated ecosystems along a waterbody through which energy, materials, and water pass.” (https://www.epa.gov/sites/production/files/2015-09/documents/czara_chapter7_wetlands.pdf , EPA “Chapter 7: Management Measures for Wetlands, Riparian Areas, and Vegetated Treatment Systems,” (Buffer Zone Guidebook Sections 1.2 and 1.3.3).
riparian corridors (not capitalized)	For the purposes of the Buffer Zone Guidebook, includes riparian areas, zones, and corridors, and are not restricted to either the first 100 feet from the top of Inland Bank or 200 feet from the Mean Annual High Water of a perennial stream (e.g. Riverfront Area) under the WPA. (Buffer Zone Guidebook Section 1.2)
Riverfront Area	Refers to regulatory areas defined at MA WPA regulations 310 CMR 10.58 (Buffer Zone Guidebook Sections 1.2 and 1.3.1.2 and Appendix E).
sedimentation controls	Measures or practices that slow stormwater runoff and trap or filter sediment.
sequester	In the context of ecological processes, “sequester” refers to, “...the photosynthetic removal of CO ₂ from the atmosphere and its conversion into cellulose and other carbon compounds in plants, and its conversion from decaying plants into soil organic matter.” (Moomaw et al. 2018) “The term “carbon sequestration” is used to describe both natural and deliberate processes by which CO ₂ is either removed from the atmosphere or diverted from emission sources and stored in the ocean, terrestrial environments (vegetation, soils, and sediments), and geologic formations”. https://pubs.usgs.gov/fs/2008/3097/pdf/CarbonFS.pdf
sheet flow/sheet runoff	Overland (i.e. not channelized) flow that is relatively uniform in depth. (Buffer Zone Guidebook Section 2.3.1.1. “Sheet runoff is the broad, relatively unconfined downslope movement of water across sloping terrain that results from many sources, including intense rainfall and/or snowmelt, overflow from a channel that crosses a drainage divide, overflow from a perched channel onto deltas or plains of lower elevation, and overland flow in urban areas. Generally, sheet runoff enters a channel or drainage system that intersects its flow, but occasionally it dissipates before reaching a channel. Sheet

	<p>runoff is typical in areas of low topographic relief and poorly established drainage systems and should not exceed depths of 3.0 feet.”</p> <p>https://www.fema.gov/media-library-data/1484865782763-4d150592d6eae9fdb5e2c2ab597928a6/Shallow_Flooding_Guidance_Nov_2016.pdf</p>
vegetated buffers/buffer strips	<p>See “buffers and buffer zones” above, and Buffer Zone Guidebook Sections 1.2 and 1.3.3.</p> <p>[Vegetative] “Buffers and filter strips are areas of permanent vegetation located within and between agricultural fields and the water courses to which they drain. These buffers are intended to intercept and slow runoff thereby providing water quality benefits. In addition, in many settings they are intended to intercept shallow groundwater moving through the root zone below the buffer”.</p> <p>https://www.epa.gov/sites/production/files/2015-07/documents/2006_8_24_msbasin_symposia_ia_session4-2.pdf</p> <p>“Conservation buffers are small areas or strips of land in permanent vegetation, designed to intercept pollutants and manage other environmental concerns. Buffers include: riparian buffers, filter strips, grassed waterways, shelterbelts, windbreaks, living snow fences, contour grass strips, cross-wind trap strips, shallow water areas for wildlife, field borders, alley cropping, herbaceous wind barriers, and vegetative barriers...Buffer strips can also enhance wildlife habitat and protect biodiversity.”</p> <p>https://www.nrcs.usda.gov/wps/portal/nrcs/detail/?cid=nrcs143_023568</p>
vernal pools	<p>Temporary fishless ponds that typically fill in the autumn or winter, remaining ponded through the spring and into summer, but drying by mid to late summer. These ponds support many amphibians and invertebrates that rely on a fishless environment for reproduction. https://www.mass.gov/vernal-pools</p>

ACRONYMS/ABBREVIATIONS

310 CMR – 310 Code of Massachusetts Regulations

AAC – (Massachusetts) Climate Change Adaptation Advisory Committee

ASWM – Association of State Wetland Managers

CZM – Massachusetts Office of Coastal Zone Management

ELI – Environmental Law Institute

EEA – (Massachusetts) Executive Office of Energy and Environmental Affairs

GMSL – Global Mean Sea Level

GWSA – (Massachusetts) Global Warming Solutions Act

IPCC – Intergovernmental Panel on Climate Change: <http://www.ipcc.ch/>

Km – Kilometers

MA – Massachusetts

MAHW – Mean Annual High Water

MACC – Massachusetts Association of Conservation Commissions

MassDEP – Massachusetts Department of Environmental Protection

MassGIS – Massachusetts Geographic Information System

MOR – Mouth of River

MVP – Municipal Vulnerability Preparedness Program

NHANRS – New Hampshire Association of Natural Resource Scientists

NOAA – National Oceanic and Atmospheric Administration: <https://www.noaa.gov/>

RCP – Representative Concentration Pathways

RFA – Riverfront Area

USGS – United States Geological Survey

WPA – (Massachusetts) Wetlands Protection Act

APPENDIX B – BUFFER ZONE PROJECT FILING PROCEDURES AND EXEMPT MINOR ACTIVITIES

The following sections of the Massachusetts Wetlands Protection Act regulations (310 CMR 10.00 et al) pertain to the Buffer Zone:

310 CMR 10.02(2)(b):

(b) Activities Within the Buffer Zone. Any activity other than minor activities identified in 310 CMR 10.02(2)(b)2. proposed or undertaken within 100 feet of an area specified in 310 CMR 10.02(1)(a) (hereinafter called the Buffer Zone) which, in the judgment of the issuing authority, will alter an Area Subject to Protection under M.G.L. c. 131, § 40 is subject to regulation under M.G.L. c. 131, § 40 and requires the filing of a Notice of Intent. (See also 310 CMR 10.05(3)(a)2.). The areas subject to jurisdiction identified in 310 CMR 10.02(1)(b) through (f) do not have a buffer zone.

1. Minor activities, as described in 310 CMR 10.02(2)(b)2., within the buffer zone and outside any areas specified in 310 CMR 10.02(1)(a) through (e) are not otherwise subject to regulation under M.G.L. c. 131, § 40 provided that the work is performed: solely within the buffer zone, as prescribed in 310 CMR 10.02(2)(b)2.a. through q., in a manner so as to reduce the potential for any adverse impacts to the resource area during construction, and with post-construction measures implemented to stabilize any disturbed areas. Factors to consider when measuring the potential for adverse impacts to resource areas include the extent of the work, the proximity to the resource area, the need for erosion controls, and the measures employed to prevent adverse impacts to resource areas during and following the work.

2. The following minor activities, provided that they comply with 310 CMR 10.02(2)(b)1., are not otherwise subject to regulation under M.G.L. c. 131, § 40:

- a. Unpaved pedestrian walkways less than 30 inches wide for private use and less than three feet wide for public access on conservation property;
- b. Fencing, provided it will not constitute a barrier to wildlife movement; stonewalls; stacks of cordwood;
- c. Vista pruning, provided the activity is located more than 50 feet from the mean annual high water line within a Riverfront Area or from Bordering Vegetated Wetland, whichever is farther. (Pruning of landscaped areas is not subject to jurisdiction under 310 CMR 10.00.);
- d. Plantings of native species of trees, shrubs, or groundcover, but excluding turf lawns;
- e. The conversion of lawn to uses accessory to residential structures such as decks, sheds, patios, pools, replacement of a basement bulkhead and the installation of a ramp for compliance with accessibility requirements, provided the activity, including material staging and stockpiling is located more than 50 feet from the mean annual high-water line within the Riverfront Area, Bank or from Bordering Vegetated Wetland, whichever is

farther, and erosion and sedimentation controls are implemented during construction. The conversion of such uses accessory to existing single family houses to lawn is also allowed. (Mowing of lawns is not subject to jurisdiction under 310 CMR 10.00);

f. The conversion of impervious to vegetated surfaces, provided erosion and sedimentation controls are implemented during construction;

g. Activities that are temporary in nature, have negligible impacts, and are necessary for planning and design purposes (e.g., installation of monitoring wells, exploratory borings, sediment sampling and surveying and percolation tests for septic systems provided that resource areas are not crossed for site access);

h. Installation of directly embedded utility poles and associated anchors, push braces or grounding mats/rods along existing paved or unpaved roadways and private roadways/driveways, and their existing maintained shoulders, or within existing railroad rights-of-way, provided that all work is conducted within ten feet of the road or driveway shoulder and is a minimum of ten feet from the edge of the Bank or Bordering Vegetated Wetland and as far away from resource areas as practicable, with no additional tree clearing or substantial grading within the buffer zone, and provided that all vehicles and machinery are located within the roadway surface during work;

310 CMR 10.24(1):

10.24: General Provisions

(1) If the issuing authority determines that a resource area is significant to an interest identified in M.G.L. c. 131, § 40 for which no presumption is stated in the Preamble to the applicable section, the issuing authority shall impose such conditions as are necessary to contribute to the protection of such interests. For work in the buffer zone subject to review under 310 CMR 10.02(2)(b)3., the issuing authority shall impose conditions to protect the interests of the Act identified for the adjacent resource area. The potential for adverse impacts to resource areas from work in the buffer zone may increase with the extent of the work and the proximity to the resource area. The issuing authority may consider the characteristics of the buffer zone, such as the presence of steep slopes, that may increase the potential for adverse impacts on resource areas. Conditions may include limitations on the scope and location of work in the buffer zone as necessary to avoid alteration of resource areas. The issuing authority may require erosion and sedimentation controls during construction, a clear limit of work, and the preservation of natural vegetation adjacent to the resource area and/or other measures commensurate with the scope and location of the work within the buffer zone to protect the interests of M.G.L. c. 131, § 40. Where a buffer zone has already been developed, the issuing authority may consider the extent of existing development in its review of subsequent proposed work and, where prior development is extensive, may consider measures

such as the restoration of natural vegetation adjacent to the resource area to protect the interests of M.G.L. c. 131, § 40. The purpose of preconstruction review of work in the buffer zone is to ensure that adjacent resource areas are not adversely affected during or after completion of the work.

310 CMR 10.53(1):

10.53: General Provisions

(1) If the Issuing Authority determines that a Resource Area is significant to an interest identified in M.G.L. c. 131, § 40 for which no presumption is stated in the Preamble to the applicable section, the Issuing Authority shall impose such conditions as are necessary to contribute to the protection of such interests. For work in the Buffer Zone subject to review under 310 CMR 10.02(2)(b)3., the Issuing Authority shall impose conditions to protect the interests of the Act identified for the adjacent Resource Area. The potential for adverse impacts to Resource Areas from work in the Buffer Zone may increase with the extent of the work and the proximity to the Resource Area. The Issuing Authority may consider the characteristics of the Buffer Zone, such as the presence of steep slopes, that may increase the potential for adverse impacts on Resource Areas. Conditions may include limitations on the scope and location of work in the Buffer Zone as necessary to avoid alteration of Resource Areas. The Issuing Authority may require erosion and sedimentation controls during construction, a clear limit of work, and the preservation of natural vegetation adjacent to the Resource Area and/or other measures commensurate with the scope and location of the work within the Buffer Zone to protect the interests of M.G.L. c. 131, § 40. Where a Buffer Zone has already been developed, the Issuing Authority may consider the extent of existing development in its review of subsequent proposed work and, where prior development is extensive, may consider measures such as the restoration of natural vegetation adjacent to a Resource Area to protect the interest of M.G.L. c. 131, § 40. The purpose of preconstruction review of work in the Buffer Zone is to ensure that adjacent Resource Areas are not adversely affected during or after completion of the work.

APPENDIX C - SAMPLE SPECIAL CONDITIONS

When issuing a decision, conservation commissions prepare Special Conditions that pertain to the specific project at hand. In general, Special Conditions relevant to Buffer Zone and Riverfront Area protection should be written to ensure protection of the Interests of the Act and all ecosystem services/functions protected by the MA WPA Regulations and/or Bylaw/Ordinance for the adjacent Resource Area and the Buffer Zone. They should reflect consideration of the factors outlined in previous sections of this Guidebook.

Conditions may:

- Limit the scope of project by reviewing avoidance, minimization, and mitigation requirements and mitigation specifications;
- Identify closest allowable disturbance;
- Identify closest allowable impervious surface or structure;
- Provide erosion and sedimentation control requirements;
- Require a clear limit of work;
- Provide pre-construction, construction and post-construction phase monitoring and inspection requirements;
- If stipulated in the local Bylaw/Ordinance, mitigation may be required for Buffer Zone impacts or for Riverfront Area buffering functions beyond state Riverfront Area requirements;
- Address cumulative impacts:
 - Extent of existing development in Buffer Zone/Riverfront Area may be considered.
 - Where existing development is extensive (or where required by local Bylaw/Ordinance), the Conservation Commission may require restoration of natural vegetation within the Buffer Zone, with preference given to restoration adjacent to wetlands and waters.

Sample Special Conditions Under the Massachusetts Wetlands Protection Act and a Municipal Wetlands Protection Bylaw or Ordinance

The following sample special conditions are provided as examples only, and MACC recommends the use of only a subset of these conditions in any specific Order. Conditions should be relevant to specific projects and used on a case-by-case basis. Additionally, this list includes some conditions that would only be relevant for Bylaws/Ordinances, and not for the WPA regulations. Commissions should confirm that any use of the sample special conditions is relevant to the regulation being implemented and to the specifics of the project at hand.

General

- All construction materials, earth stockpiles, landscaping materials, slurry pits, waste products, refuse, debris, stumps, slash, or excavate may only be stockpiled or collected in areas as shown and labeled on the approved plan(s), or if no such areas are shown must be placed or stored outside all resource areas and associated buffer zones under cover and surrounded by a double-staked row of hay bales to prevent contact with rain water.
- No material of any kind may be buried, placed or dispersed in areas within the jurisdiction of the Commission by activities that are the subject of this Order, except as are expressly permitted by this Order or the plans approved herein.
- All waste products, grubbed stumps, slash, construction materials, etc. shall be deposited at least 100 feet from wetland resource areas and 200 feet from rivers, unless specified in this Order.
- No fuel, oil, or other pollutants shall be stored in any resource area or the buffer zone thereto, unless specified in this Order.
- Any material placed in wetland resource areas by the applicant without express authorization under this Order shall be removed by the applicant upon demand by the Conservation Commission or its agent.
- There shall be no underground storage of fuel or other hazardous substance in areas within the jurisdiction of the Conservation Commission.
- No clearing of vegetation, including trees, or disturbance of soil shall occur prior to the Pre-Activity Meeting. Minimal disturbance of shrubs and herbaceous plants may be allowed prior to the Pre-Activity Meeting if absolutely necessary in order to place erosion control marker stakes where required.

Installing Wetland Flags, Limits of Work, and Erosion Controls

- At any time before, during or after construction, and until the issuance of a Certificate of Compliance, the Commission or its agent may require the applicant to modify, augment, restore or maintain erosion control measures associated with the activity that is the subject of this Order.
- Prior to the Pre-Activity Meeting and commencement of any activity on this site, the approved erosion control shall be installed as indicated on the approved plan.
- Immediately after the Pre-Activity Meeting, all erosion controls shall be installed along the approved and staked line. Erosion controls shall be installed with minimal disturbance to vegetation. Where possible, erosion controls should go *around* trees, shrubs, and other vegetation, on the uphill side.
- Immediately after installation of erosion controls, the Conservation Commission shall be contacted in order to conduct a follow-up inspection to ensure that erosion controls have been properly installed.

- Prior to commencement of any activity on the site, all wetland resource area boundaries shall be flagged and inspected by the Conservation Commission or their representative.
- Sedimentation barriers and orange safety fence shall serve as the limit of work unless another limit of work line has been approved by this Order. Construction equipment is prohibited beyond installed siltation barrier.
- Prior to the commencement of any earth moving activity, an erosion barrier consisting of both a siltation fence and an organic barrier or tube shall be properly installed as shown on the Plan of Record. All erosion controls shall be invasive free (salt marsh hay, straw wattles, or other invasive-free product). The siltation fence shall be placed on the down-gradient side of the organic barrier, and be firmly entrenched 4 to 6 inches in depth and well supported by stakes.

OR

- Prior to the commencement of any earth moving activity, an erosion barrier consisting of siltation fence only shall be properly installed as shown on the Plan of Record. This fence shall be the line establishing the Limit of Work. Silt retention fabric must be staked and entrenched at least six (6") inches for maximum siltation control prior to any construction or site preparation. To allow wildlife movement, long sections of filter fence or haybales shall be installed in 50-foot sections, leaving a one-foot gap between them. The gap shall be protected from siltation by placing a six-foot section of fence or bales across it on the uphill side and one foot away from it, so there is an overlap of about three feet on either side.
- Orange Safety Fence (or equivalent) must be installed as per the approved plans as a limit of work line and must remain in place until a Certificate of Compliance is issued. ½-inch diameter steel rebar rods or steel fence posts approximately 5 1/2 feet long must be placed 4 feet apart and driven 1 foot into the ground. The fence is to be firmly tied to the rods with wire.

Staging Area/Construction Equipment/Site Cleanup

- Prior to construction the general contractor shall designate a construction staging area, located outside all resource areas and buffer zones. All construction trailers, portable sanitary facilities, material storage and overnight parking of equipment shall be in the staging area. The perimeter of the staging area shall be protected as necessary with silt fence and the ground surface shall be protected with washed stone or another suitable non-erosive material.

Stormwater Management: Erosion and Sedimentation Control

- All materials that are stockpiled or stored shall be protected from erosion with haybales, silt fence, or mulch. All materials shall be stockpiled at least 50 feet away from wetlands, and at a location to prevent sediment from surface runoff entering the wetlands. At no time shall any debris or other material be buried or disposed of within the Buffer Zone, other than such fill as is allowed by this Order and as shown on the above-referenced plans.

- All erosion and sedimentation control devices shall be:
 - inspected daily and after each storm event,
 - maintained in good repair, cleaned, repaired, or replaced throughout construction (and any accumulated silt adjacent to the barriers shall be removed) and
 - left in place until such time as permanent stabilization of all areas that may impact wetland resource areas has been achieved.
- All construction areas shall be in a stable condition at the close of each construction day. Erosion controls should be inspected at this time, and repaired, reinforced or replaced as necessary.
- The Applicant shall immediately control any erosion problems that occur at the site and shall also immediately notify the Conservation Commission, which reserves the right to require additional erosion and/or damage prevention controls it may deem necessary.
- If soils are to be disturbed for longer than 30 days, they shall be temporarily stabilized. Temporary stabilization methods may include, but not be limited to, rye grass, hydro-seeding, straw mats, jute netting, sod, or other Commission approved method.
- All disturbed areas will be graded, loamed and seeded prior to November 1 of each year, if possible. No disturbed areas or stockpiled material will be left unprotected or without erosion controls during the winter.

Wildlife

- Where erosion controls have been placed in areas between uplands and vernal pools, exposed soils are to be stabilized, and silt fencing or other devices that could block migration of amphibians to and from the pools is to be removed, no later than March 1 if construction has been occurring during the winter, and no later than September 1 if construction has been occurring during the summer. If soils will not be stabilized by these dates, temporary stabilization measures shall be emplaced and sedimentation barriers shall be designed to provide a gradual slope or berm over which amphibians may pass.
- Erosion control devices shall not block passage between uplands and vernal pools between the dates of March 1 and June 1, nor between September 1 and October 15. If soils will not be stabilized during these periods, temporary stabilization measures shall be designed to provide a gradual slope or berm over which amphibians may pass. (This condition should be specific to an erosion control and construction sequence established during the public hearing and submitted as part of the approved plans submitted and approved by the Commission.)

Stormwater

- Runoff shall be directed through vegetated swales before discharging into stormwater control structures.
- All roof runoff except that from metal roofs shall discharge into drywells. Drywells shall be sized to accept the first 0.5 inch of runoff (except where prohibited due to ground water conditions, etc. (See Stormwater Management Policy)).
- A naturally vegetated buffer or filter strip shall be maintained between the (developed area) and the wetland resource area.
- Catch basins shall be equipped with sumps, oil and gas traps, and shall be inspected and cleaned on a semi-annual basis. After each inspection and cleaning, the inspector shall provide to the Commission written confirmation that the inspection and cleaning were conducted.
- All catch basin discharge points, or other point source discharge points, shall be riprapped to disperse stormwater energy
- Catch basins shall be inspected and cleaned on a semi-annual basis. After each inspection and cleaning, the inspector shall provide to the Commission written confirmation that the inspection and cleaning were conducted. This condition shall be noted on the Certificate of Compliance and shall continue in perpetuity.
- During construction, all drainage structures shall be inspected regularly and cleaned as necessary.
- There shall be no sedimentation into Buffer Zones, wetlands or water bodies from discharge pipes or surface runoff leaving the site.
- Immediately upon the construction of all catch basins and oil traps, haybales or similar controls shall be set around the inlet to prevent sediment from entering the drainage system. Immediately upon the installation of the headwalls and riprap, haybales or similar controls shall be set and staked around the inlet to prevent sediments from entering the drainage system
- The applicants, owners, and their successors and assignees shall maintain all culverts, collection basins, traps, retention and detention ponds, outlet structures, and other elements of drainage systems, unless put into an easement to the City/Town, in order to avoid blockages and siltation which might cause failure of the system and/or detrimental impacts to on-site or off-site resource areas, and shall maintain the integrity of vegetative cover on the site.

Final Site Stabilization and Removal of Erosion Controls

- Within 5* days of final grading on any given portion of the project, loaming and seeding will occur. (*The time period minimized to the extent possible and should be discussed at the Public Hearing.) Where necessary, the loam and seeding shall be covered with mulch

hay or held in place with jute netting or erosion control blankets or other approved means. Outside of the growing season, exposed soil finish grade surfaces shall be stabilized with a layer of invasive-free mulch hay until climate conditions allow for seeding. Continued maintenance of these areas, in a manner which assures permanent stabilization and precludes any soil erosion, shall be the responsibility of the Applicant/Owner/Assign.

- Once the site has been stabilized, the Applicant/Owner/Assign shall remove and properly dispose of all erosion controls. Removal of said erosion controls shall be accomplished utilizing the least invasive means possible. The hay may then be scattered and the erosion tube sliced and scattered, but the siltation fence and stakes must be removed and disposed of properly. The Commission will not issue a Certificate of Compliance until erosion controls are removed.

Conditions in Perpetuity

- It shall be the responsibility of the landowner to continually maintain the site in a manner that assures stabilization and precludes any soil erosion. This condition is perpetual and does not end with the issuance of a Certificate of Compliance.
- Stabilized slopes shall be maintained as designed and constructed by the property owner of record, whether “bioengineered” or mechanically-stabilized slopes.
- After completion of work and prior to the issuance of a Certificate of Compliance, the applicant shall permanently mark the limit of work approved in this Order as well as (optional) the edge of wetland areas or buffer zone to ensure no inadvertent encroachment into the wetland or buffer zone. The markers to be used shall be approved by the Conservation Commission. The applicant shall instruct all agents to explain these markers to buyers/lessees/landscapers and all persons taking over the property from the applicant. These markers shall remain in place in perpetuity.

OR

- (Bylaw). Prior to the issuance of a Certificate of Compliance permanent boundary markers shall be installed to mark the XX-foot no disturbance buffer zone. The type of permanent markers shall be approved by the Conservation Commission or its agent. These shall be shown on the as-built plan and clearly marked on the plan with a note indicating no work shall be performed beyond this point without permission from the Conservation Commission. A copy of the as-built plan shall be provided with the written request for a Certificate of Compliance. It shall be attached to and made part of the Certificate of Compliance and shall be recorded. Over the years the wetland boundary line may move, however, these permanent markers shall provide a guideline to future homeowners as to the limit of work.
- As the proposed project utilizes the maximum limit of Riverfront Area permitted under the Massachusetts Wetland Protection Regulations, no further activities will be permitted on the balance of the subject parcel with the exception of maintenance of this area, unless they are filed as a Limited Project under 310 CMR 10.53(3), or are exempt under 310 CMR 10.58. This Condition will be noted on the Certificate of Compliance.

APPENDIX D – GREEN TREE ESTATES CASE STUDIES

OVERVIEW

The case studies presented in this Appendix allow conservation commissions the opportunity to apply the information learned from their review of the MACC Buffer Zone Guidebook. MACC provides the scenarios and questions below as a starting point and a training opportunity for conservation commissions, as you analyze and discuss responses to the two case studies provided (see attached Green Tree Estates Plans). Conservation commissions may develop Findings and Special Conditions that are appropriate to the two case studies, and in this endeavor, may find it useful to reference various chapters and appendices in the Buffer Zone Guidebook and the sample Special Conditions provided in Appendix C. The two case studies are provided to allow Commissions to practice reviewing specific projects, using the attached Green Tree Estates Plans. **These case studies and the Green Tree Estates Plans are fictional, and are not based on any specific project in the real world, but instead are suggestive of the types of situations Commissions may find themselves facing when reviewing projects.**

CASE STUDY #1: SINGLE FAMILY HOUSE SCENARIO

Apple Country Developer wants to build a single-family house and driveway on Lot 2. House and driveway are partially in the Buffer Zone, and the house is partially on a 17% slope. There is a Certified Vernal Pool located 15 feet inside the Bordering Vegetated Wetland (BVW), home to the New England Spotted Water Python*. Water will be supplied from a well located downgradient of the driveway. The developer is proposing landscaping and mowed lawn right up to the edge of the BVW. Sewer lines preclude the need for a septic system. Sewer lines are to be installed 20 feet downgradient from the driveway, between the house and the road. The Buffer Zone is currently forested.

Scientific literature available to you:

1. Newly released study: *New England Spotted Water Python (Slytherin et al 2018): breeds in vernal pools and overwinters in nests in upland oak trees, as much as 1,000 feet from breeding areas. Highly sensitive to elevated levels of road salt, pesticides and fertilizer.
2. See earlier sections of the Guidebook for relevant tables based on scientific literature.

Review Process:

Consider the Resource Area(s):

1. Adjacent to and/or downgradient from the Buffer Zone, what Resource Areas are within Conservation Commission jurisdiction for this project?
2. What Interests of the Act do these Resource Areas protect?
3. What is the condition of each of the Resource Areas?
 - a. See list of considerations in Section 3.1.2.
4. Are there any sensitive areas or species?

Consider the Buffer Zone:

1. What is the condition of the Buffer Zone?

- a. See list of considerations in Section 3.1.3.

Consider the nature of the Work:

1. What is the type, scale and scope of the proposed work?
2. Will the proposed work diminish the capacity of the Buffer Zone to protect the adjacent Resource Area Interests of the Act?
3. See list of considerations in Section 3.1.4 and Section 3.1.5 and Section 3.1.6.1.

What are your Findings?

1. See list of considerations for Findings in Section 3.2.2.
2. What science can you reference to support your Findings?
3. How will your Findings support the Conditions that you will place on the project if you approve the project, and how will they support a denial if you will issue a denial?

Exercise: What are 3 Conditions that you will place on the Project, assuming you approve the project as presented? Alternatively, if you can't approve the project as presented, what changes will you request before finalizing your decision?

1. See list of considerations for Conditions in Section 3.1.6.2 and sample Conditions at beginning of Appendix C.

CASE STUDY #2: COMMERCIAL DEVELOPMENT SCENARIO – The Route 66 Restaurant

The Route 66 Company, owned by Jackson Carowhack and Hunt Er Thomasson, wants to build a farm to table restaurant (with rooftop garden), and associated solar-panel parking lot and detention pond. The proposed footprint occupies most of Lot 1. The building and parking lot are partially in the Buffer Zone, and partially on a 5% slope. The Applicant is interested in being Green and is proposing solar panels over the parking lot. The detention pond is completely within the Buffer Zone. The building and detention pond are partially within the 100-year flood zone. A roof garden where they will be growing their produce is proposed, but there is no indication as to where excess roof water will be directed. There is a Certified Vernal Pool on the far side of Rock Creek (more than 100 feet from the project) within the Bordering Vegetated Wetland (BVW), home to the New England Spotted Water Python*. Water and sewer lines will be installed from South Street. The developer is proposing landscaping and mowed lawn right up to the edge of the BVW. The Buffer Zone is currently forested, except within 40 feet of South Street, where it is a mix of common reed (*Phragmites australis*), Asian bittersweet (*Celastrus orbiculatus*), and European buckthorn (*Rhamnus cathartica*).

Scientific literature available to you:

1. Newly released study: *New England Spotted Water Python (Slytherin et al 2018): breeds in vernal pools and overwinters in nests in upland oak trees, as much as 1,000 feet from breeding areas. Highly sensitive to elevated levels of road salt, pesticides and fertilizer.
2. See earlier sections of the Guidebook for relevant tables based on scientific literature.

Review Process:

Consider the Resource Area(s)

1. Adjacent to and/or downgradient from the Buffer Zone, what Resource Areas are within Conservation Commission jurisdiction for this project?
2. What Interests of the Act do these Resource Areas protect?
3. What is the condition of each of the Resource Areas?
 - a. See list of considerations in Section 3.1.2.
4. Are there any sensitive areas or species?

Consider the Buffer Zone

1. What is the condition of the Buffer Zone?
 - a. See list of considerations in Section 3.1.3.

Consider the nature of the Work

1. What is the type, scale and scope of the proposed work?
 - a. See list of considerations.
2. Will the proposed work diminish the capacity of the Buffer Zone to protect the adjacent Resource Area Interests of the Act?
3. See list of considerations in Section 3.1.4 and Section 3.1.5 and Section 3.1.6.1.

What are your Findings?

1. See list of considerations for Findings in Section 3.2.2.
2. What science can you reference to support your Findings?
3. How will your Findings support the Conditions that you will place on the project if you approve the project, and how will they support a denial if you will issue a denial?

Exercise: What are 3 Conditions that you will place on the Project, assuming you approve the project as presented? Alternatively, if you can't approve the project as presented, what changes will you request before finalizing your decision?

1. See list of considerations for Conditions in Section 3.1.6.2 and sample Conditions at beginning of Appendix C.

GENERAL DISCUSSION QUESTIONS FOR BOTH CASE STUDIES

1. What information is required and necessary for the Applicant to submit to allow the Conservation Commission to conduct its review?
2. Is there information from a site walk by the Conservation Commission, Conservation Agent or peer reviewer that should be considered? For the purposes of the case studies, conservation commissions can make assumptions that x, y or z was found during site walks.
3. What regulated Wetland Resource Areas are downgradient from proposed work?

APPENDIX E -- SUMMARY GUIDE TO RIVERFRONT AREA REGULATIONS

Under the law, the Riverfront Area is a resource area in itself and **not a buffer zone**. The resource area extends 200 feet outward from “rivers,” with exceptions in designated urbanized areas and for certain agricultural projects. The Riverfront Area does not replace other resource areas, such as wetlands and floodplains, which are frequently present near streams. It adds another, somewhat stronger, layer of protection. Only rivers defined as perennial can have regulatable Riverfront Areas.

Work proposed by an applicant in a regulatable Riverfront Area must be designed to meet four performance standards (310 CMR 10.58(4)):

1. Meeting the performance standards for every other resource area that is present in the Riverfront Area (310 CMR 10.58(4)(a))
2. Having no adverse effect on certified vernal pools or habitat of rare species (310 CMR 10.58(4)(b)).
3. Performing a formal alternatives analysis and proving there is “no practicable and substantially equivalent economic alternative” to the project (310 CMR 10.58(4)(c))
4. Having no significant adverse impact on the Riverfront Area (310 CMR 10.58(4)(d)).

All work in the Riverfront Area is subject to an “alternatives analysis” and must meet other strict performance standards, with some exceptions. Most of the early disputes and appeals focused on jurisdictional questions, including the location of the Mean Annual High Water line, how to tell whether a stream is intermittent or perennial, and the location of the mouth of the river. These have been addressed through revisions to the regulations in 1998, 2000, and 2005.

Definition of a River

The Rivers Protection Act calls all perennial streams and rivers “rivers.” Under the Regulations, perennial streams are rivers; intermittent streams are not rivers; a canal is not a river. As stated in 310 CMR 10.58(2)(a)(1),

“A river is any natural flowing body of water that empties to any ocean, lake, pond or other river and which flows throughout the year. Rivers include streams (see 310 CMR 10.04: Stream) that are perennial...”

In 310 CMR 10.04, a stream is

“a body of running water, including brooks and creeks, which moves in a definite channel in the ground due to a hydraulic gradient, and which flows within, into or out of an Area Subject to Protection under the Act. A portion of a stream may flow through a culvert or beneath a bridge. Such a body of running water which does not flow throughout the year (i.e., which is intermittent) is a stream except for that portion upgradient of all bogs, swamps, wet meadows, and marshes”.

The only portions of any stream subject to the Wetlands Protection Act are those with evidence of above-ground flow. Man-made channels, swales, drainage ditches, culverts, and agricultural trenches are protected as streams if they drain up-gradient to resource areas.

In order to be considered a “stream” under the Wetlands Regulations, an intermittent stream must flow out of or within a marsh, swamp, wet meadow, or bog. Upgradient of the wetland vegetation, the intermittent channel is not legally a “stream” and is not subject to the conservation commission’s jurisdiction under the Act. Some intermittent streams may be important in bringing stormwater flows into wetland areas, but this function is not recognized under the Act.

Distinguishing Between Perennial and Intermittent

A stream is perennial if it flows all year (310 CMR 10.58), except during periods of drought as defined by the *Massachusetts Drought Management Plan* (see 310 CMR 10.58(2)(f)), or unless it is subject to withdrawals or controlled by dams or other restricting structures. Perennial streams generally drain a medium to large watershed or are the outlet of a large upgradient vegetated wetland, lake or pond. An intermittent or ephemeral stream does not flow year-round. It may flow in all seasons except during the driest summer months, or only after precipitation, or when groundwater levels or water from snowmelt are high.

Determination of whether a particular section of a river is perennial or intermittent can be difficult, especially if it is a very small stream. Water flowing at the time of a field visit is not proof the section is perennial. It may be dry most of the time. To address early difficulties MassDEP amended the Riverfront Area section of the regulations to establish specific criteria defining when a river is considered perennial. This is important because only rivers defined as perennial can have regulatable Riverfront Areas. The criteria are laid out in 310 CMR 10.58(2)(a)(1)(a-f) and are summarized here. Note: This summary is no substitute for the actual text of the regulations, which provides the detail commissions need to evaluate a particular situation when a project is before them.

A river is presumed perennial if any of the following criteria exist.

- A river or stream is shown as perennial on the current United States Geological Survey (USGS) maps (or a more recent map provided by MassDEP).
- A river or stream is shown as intermittent or not shown on the current USGS or MassDEP map but has a watershed size greater than one square mile.
- A river or stream shown as intermittent or not shown on the above maps, and has a watershed size less than one square mile, is intermittent unless:
 - The stream has a watershed size of at least one-half (0.5) square mile and has a predicted flow rate greater than or equal to 0.01 cubic feet per second at the 99 percent flow duration using the USGS StreamStats method (see below). Then the stream is considered perennial.
 - The USGS StreamStats method cannot be used because the stream does not have a mapped centerline, or the map is incorrect, and the stream has a watershed size of at least one-half (0.5) square mile, and the surficial geology of the drainage area at a

specific project location contains 75 percent or more stratified drift. Then that stream will be considered perennial.

- The entire length and width of over 20 of Massachusetts' major rivers are considered perennial and are listed in 310 CMR 10.58(2)(a)(1)(e).
- Perennial streams that cease to flow in periods of extended drought and/or are naturally perennial but significantly affected by withdrawals, drawdowns or certain other human-induced factors are considered perennial. Drought is explained in 310 CMR 10.00.

MassDEP relied on the Massachusetts Surface Water Quality Standards regulations at 314 CMR 4.06 for a map and description of the watershed basins that tend to have significant amounts of stratified drift (sand and gravel that has been sorted and layered by glacial meltwater). These are listed in 310 CMR 10.58(2)(a)(1).

StreamStats is an interactive online computer program developed by USGS and MassGIS and available on the USGS website. It can provide stream flow information for selected locations along most Massachusetts streams. The available data includes the peak and low flow rates of water, how frequently each occurs, and how long they persist. MACC recommends that commissions become familiar with StreamStats and review streams in their communities. The commission should request that StreamStats data be submitted as part of a Notice of Intent filing if there is a debate on whether a waterway is perennial or intermittent. The commission or MassDEP can define a stream as intermittent if documented field evidence is provided by a competent source and according to specific criteria laid out in the regulations. (Note: 310 CMR 10.58(2)(a)(1)(d) defines competent sources: "MassDEP staff, conservation commissioners, and conservation commission staff are competent sources; issuing authorities may consider evidence from other sources that are determined to be competent."). The stream must be shown not to be flowing for four days in any consecutive twelve-month period.

Nothing beats personal observation. MACC recommends that commissions observe the streams in their communities in late summer and early fall (at least via roads) and note on a map which streams are flowing and which streams are not flowing during the dry months. Local stream teams and watershed associations can be helpful in this effort.

Start and Mouth of a River

Start of a River. According to 310 CMR 10.58(2)(a), a river begins where an intermittent stream becomes perennial, or at a spring or the outlet of a pond that discharges water throughout the year. Within a large watershed or river basin there may be many such points. Small rivers join to form larger and larger rivers that flow eventually to the ocean.

Mouth of a River. When a river flows into the ocean, it ceases to be a river and has no Riverfront Area. The regulations address the mouth or downstream limit of a river in 310 CMR 10.58(2)(c).

"When a river flows into coastal waters or an embayment, the river shall end at the mouth of coastal river line as delineated on the current mouth of coastal river map series..."

MassDEP published [Mouth of Coastal Rivers Maps](#) in March 2005 in an effort to alleviate the considerable difficulties that had arisen in determining the river mouth. These maps identify the seaward jurisdictional

extent of Riverfront Area for all USGS-mapped perennial rivers in Massachusetts coastal communities by providing a designated Mouth Of River (MOR) line. These maps only apply to coastal communities on the north and south shores. The MOR lines represent the limit of Riverfront Area jurisdiction under the Wetlands Protection Act. Any land seaward of the MOR line is not subject to jurisdiction as a Riverfront Area but remains subject to other inland and coastal provisions of the Wetlands Protection Act. MassDEP placed their MOR lines based on the following criteria:

- End of parallel Banks – the point at which a line drawn from one Bank to the other is no longer perpendicular to the river
- Visual characteristics of an apparent sub-marine channel on orthophoto maps
- Identifiable landward edge of Bank interface with Coastal Beach or vegetated Dune
- Seaward edge of Salt Marsh
- Inland of named features shown on the most current USGS map – including coves, harbors, bays, embayments, salt ponds (including those with CZM salt pond designation), sounds, and “guts” and “straights” that connect ocean feature to ocean feature
- Downstream side of a control structure designed as a barrier to coastal flooding (e.g., dike, tide gate, or solid fill causeway).

Presence of a mapped MOR line cannot be used as evidence that a river is perennial.

When is a River Not a River? A Look at Lakes, Ponds (versus Riverine Characteristics), and Culverts, and Named Rivers

All perennial rivers, regardless of size, have Riverfront Areas except:

- Along some lakes and ponds, and
- Along culverts greater than 200 feet in length.

Where rivers broaden into lakes and ponds there is only a Riverfront Area along the lake or pond when the flowing water displays “riverine” characteristics (310 CMR 10.58(2)(a)(1)(e)). The Wetlands Protection Act defines these characteristics as “unidirectional flow that can be visually observed or measured in the field...” and notes that rivers “are characterized by horizontal zonation, as opposed to the vertical stratification typically associated with lakes, ponds and embayments.” Of note, however, the Act states that Great Ponds cannot be rivers, and §10.58(2) of the regulations says that listed Great Ponds are never rivers.

Recent MassDEP decisions give further insight into other primarily riverine attributes that are considered critical. Making these determinations will often, if not always, require an expert. The characteristics include:

- The presence of a channel within the waterbody;
- Historic changes such as dams and control structures;

- Surface or subsurface withdrawal (for instance, the proximity of a municipal well);
- Residence time (the length of time between when water enters and exits the lake or pond);
- The ratio of the watershed size to the impoundment or pond size; and
- More pronounced unidirectional flow through the center of the waterbody as compared to other areas (a manifestation of horizontal zonation).
- Finally, in **Matter of Kamionek**, Docket No. 2001-075, Final Decision (February 14, 2005) it was also noted that the morphology of a waterbody, with roughly parallel banks, as opposed to a more rounded shape, is a riverine characteristic.

Differences in color, turbidity, and algae may be caused by many sources and are not likely to be determinative of the presence or absence of riverine characteristics.

The Riverfront Area stops at the inlet to a culvert longer than 200 feet or a lake or pond not showing riverine characteristics and begins again at the outlet (see Figure 16.24.2.4 in the [MACC Handbook](#)).

Certain major rivers have a Riverfront Area along their entire length. These are named in the law and listed in §10.58(2)(a)(1)(b).

So, in summary, Riverfront Area exists:

- Where the river is perennial, even if it dries up during an extended drought (as defined in 310 CMR 10.58(2)(a)(1)(f) or due to water withdrawals or upstream impoundments
- Along waterbodies along a river if the flow shows riverine characteristics
- Except along canals, mosquito ditches, or culverts longer than 200 feet
- Along the entire length of major rivers listed in 310 CMR 10.58(2)(a)(1)(b)

RFA Inner Boundary: Mean Annual High Water (MAHW) Line and Bankfull Conditions

The Riverfront Area (RFA) begins at the Mean Annual High Water (MAHW) line of the river and, in most cases, extending 200 feet outward from that line. “The term “Riverfront area”, as used in this section, shall mean that area of land situated between a river’s mean annual high water line and a parallel line located two hundred feet away, measured outward horizontally from the river’s mean annual high water line.” The Regulations, 310 CMR 10.58(2)(a) state: “A Riverfront Area is the area of land between a river’s mean annual high water line and a parallel line measured horizontally.”

The MAHW line as defined by the statute:

“the line that is apparent from visible markings or changes in the character of soils or vegetation due to the prolonged presence of water and that distinguishes between predominantly aquatic and predominantly terrestrial land.”

The regulations define the MAHW line as that where physical “indicators of bankfull conditions” are present (310 CMR 10.58 (2)(a)(2)). The Preface to Wetlands Regulations Relative to Mean Annual High Water, 2000 Regulatory Revisions (the Appendices to the Regulation reads:

“Bankfull discharge corresponds to the elevation, or stage of the river, that actively creates, modifies, and maintains the river’s channel. In the context of the regulations, the river’s channel can be described broadly as the cross-sectional area that carries the river’s annual high water flows, which typically occur in early spring. During bankfull discharge, the water is moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in morphologic change to the river system. These morphologic changes to the river system can be observed in the field.”

The Wetlands Regulations (310 CMR 10.58(2)(a)(2)) state:

“Bankfull field indicators include but are not limited to: changes in slope, changes in vegetation, stain lines, top of point bars, changes in bank materials, or bank undercuts.

- In most rivers, the first observable break in slope is coincident with bankfull conditions and the mean annual high water line.
- In some river reaches, the mean annual high water line is represented by bankfull field indicators that occur above the first observable break in slope, or if no observable break in slope exists, by other bankfull field indicators. These river reaches are characterized by at least two of the following features: low gradient, meanders, oxbows, histosols, a low-flow channel, or poorly-defined or nonexistent banks.

Defining the location of the MAHW line can be complex in low-gradient rivers, or rivers affected by roadway culverts and dams. Where the river is low-gradient, meandering and sinuous, MAHW may exceed the channel or top of bank every year or even more frequently. These are stretches with at least two of the following features: low gradient, meanders, oxbows, histosols, a low-flow channel, or poorly-defined or non-existent banks (310 CMR 10.58 (2)(a)(2)(b)). In these cases, MAHW is then identified by multiple corroborating field indicators which include stain lines, vegetative changes such as herbaceous to shrub/tree lines, tops of point bars, scouring and bank cuts. Typical rivers in this category include the lower reaches of the Ipswich, Concord, Sudbury and Shawsheen Rivers. Not confined to major river systems, meandering, low-flow rivers can have very small watersheds of less than one square mile, or major watersheds of more than fifty square miles.

When reviewing a complex site, it is important to remember that the Mean Annual High Water corresponds to bankfull conditions, those that are “generally doing work that results in morphologic change to the river system” i.e., that have caused the river to form its current channel bed, bank, and cross-section. The present configuration of the river has developed primarily as a result of frequent flow events, not infrequent high water flood events, or low flow conditions. Common bankfull field indicators include the break in slope on the stream bank and depositional features such as point bars that form on the inside bends of rivers. Scour and stain lines should never be used as the only bankfull indicators and should be corroborated with other indicators.

Along tidal rivers the definition of Mean High Water in 310 CMR 10.23 is used (310 CMR 10.58 (2)(a)(2)(c)).

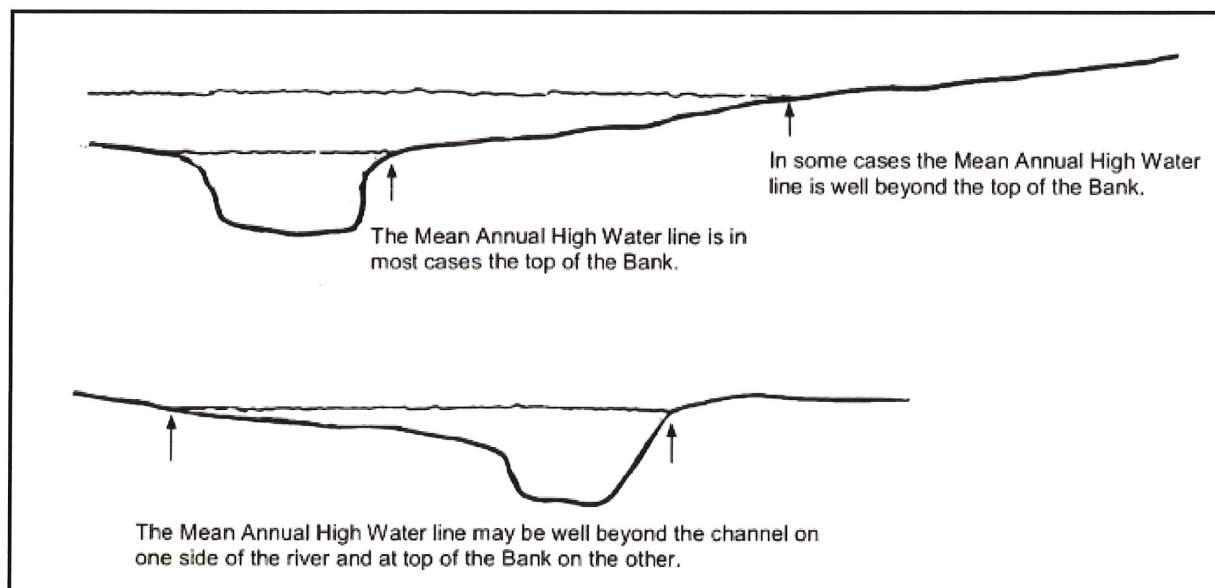


Figure 11: Mean Annual High Water Line of River/Inner Boundary of Riverfront Area. Reproduced from: MACC Handbook, Prepared by Sally Zielinski.

Outer Boundary of RFA

The Riverfront Area is 200 feet wide on each side of the river in most areas (see Figure 12). The 200-foot width is the same whether along a small perennial stream or a broad river. But there are notable exceptions:

- Where new agricultural or aquacultural projects are proposed, the Riverfront is only considered to be 100 feet wide.
- In fourteen highly urbanized cities listed in the statute and in 310 CMR 10.58(2), the Riverfront Area is only 25 feet wide.
- The law also permits municipalities to seek a reduction of the Riverfront Area from 200 to 25 feet in “densely developed” portions of the community containing at least ten acres. This requires approval of the EEA.

The outer boundary of the Riverfront Area is measured horizontally from the MAHW line and not along the potentially uneven or sloping surface of the ground (see Figure 12).

Where an intermittent stream becomes perennial the beginning of the Riverfront Area is a semi-circle drawn with a 200-foot (or 25-foot) radius around the point where the stream becomes perennial.

Where a culvert (greater than 200 feet in length) begins and ends the Riverfront Area begins at a perpendicular line drawn at the headwalls at each end of the culvert.

Riverfront Area does not have a 100-foot buffer zone.

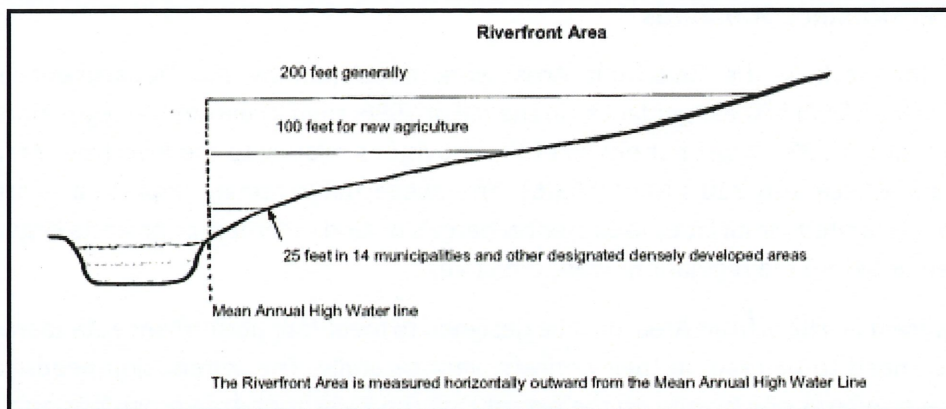


Figure 12: Width of Riverfront Area. Reproduced from: MACC Handbook, prepared by Sally Zielinski

Overlap of RFA with Other Resource Areas

The Riverfront Area may contain all or parts of other resource areas. Riverfront Area may overlap with the 100-year floodplain and therefore part of Bordering Land Subject to Flooding. It may contain Bordering Vegetated Wetlands such as forested swamps, marshes or wet meadows. Isolated Land Subject to Flooding, including vernal pools, may be present as well as coastal resource areas. See Figure 15.

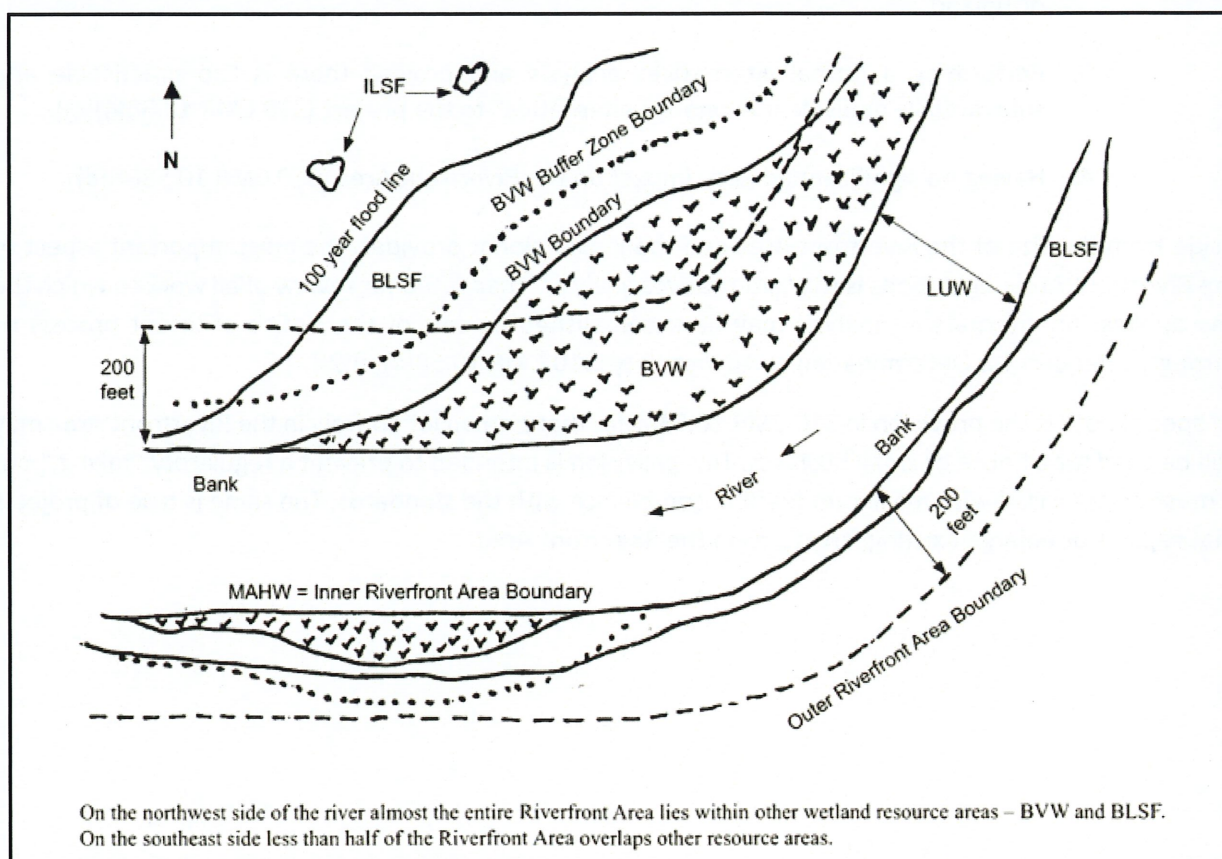


Figure 13: Overlapping Resource Areas along a River. Reproduced from: MACC Handbook, prepared by Sally Zielinski

Summary of General Performance Standards

Performance standards for work in the Riverfront Area were developed by the Department of Environmental Protection (MassDEP) first as “guidance” in the fall of 1996, then as part of the regulations that became effective in October 1997. Most but not all of the provisions relating to the Riverfront Area are found in 310 CMR 10.58 (see also 310 CMR 10.53(6)). The above dates remain important, since application of the law may be limited for facilities in existence, parcels of land recorded, or projects begun before the Act was passed or before the regulations were effective.

Work proposed by an applicant in a Riverfront Area must be designed to meet four performance standards (310 CMR 10.58(4)). These need to be read, in their entirety, very carefully. The commission needs to evaluate the performance standards one by one, to the extent that the Riverfront Area provisions apply to the site or the project, considering grandfathering, redevelopment, exemptions, and “limited” projects.

The performance standards include:

1. Meeting the performance standards for every other resource area that is present in the Riverfront Area (310 CMR 10.58(4)(a))
2. Having no adverse effect on certified vernal pools or habitat of rare species (310 CMR 10.58(4)(b)). Note that these species include all forms of rare animals, whether wetland or upland.
3. Performing a formal alternatives analysis and proving there is “no practicable and substantially equivalent economic alternative” to the project (310 CMR 10.58(4)(c)).
4. Having no significant adverse impact on the Riverfront Area (310 CMR 10.58(4)(d)).

Aside from the size of the Riverfront Area and the jurisdiction it provides, the most important aspect of the Riverfront Area regulations is the “alternatives analysis” mandated for review of all work to which the law applies. An alternatives analysis may be accomplished as part of the Notice of Intent process or through a Request for Determination of Applicability (310 CMR 10.58(4)(c)(2)).

Of special note is the provision in 310 CMR 10.58(4)(d) that a small lot entirely in the Riverfront Area may still be used for a house or small business. This provision is intended to prevent a regulatory “taking,” but it must be exercised with maximum feasible compliance with the standards. The same is true of projects that replace or enlarge existing structures in the Riverfront Area.

APPENDIX F – MODEL REGULATIONS FOR THE BUFFER ZONE UNDER THE MACC MODEL WETLANDS PROTECTION ACT BYLAW

Introduction

Conservation commissions in communities that have enacted a bylaw or ordinance for wetlands protection generally promulgate regulations with more specific requirements for the protection of resource areas and buffer zones. In considering regulations for adoption or revision, Commissions should ensure that the provisions are consistent with the intent and language of their bylaw, and do not overstep bylaw authority. MACC based its model regulations for the buffer zone on the MACC Model Wetlands Protection Act Bylaw. The MACC model bylaw and its specific provision on the buffer zone are summarized below. The MACC model regulations for the buffer zone are intended to implement the MACC model bylaw and may be tailored to another bylaw or otherwise to meet the needs of the community. To withstand judicial review, specific performance standards and setback distances should always be established in regulations rather than policies.

Summary of MACC Model Bylaw

MACC's Model Wetlands Protection Act Bylaw extends full jurisdiction to the buffer zone so that it is directly protected, as opposed to the state law where review and conditioning are contingent on adverse effects on the adjacent resource area. The Model Bylaw establishes a 100 ft. buffer zone on all resource areas except for riverfront area and land subject to flooding or coastal storm flowage. The values or interests protected include those identified in the state Act as well as erosion and sedimentation control, water quality, rare species habitat (plant and animal), agriculture, aquaculture, and recreation. Applicants have the burden of proving that proposed work will not have "unacceptable significant or cumulative effect" upon the protected resource area values. In issuing permits, the Commission must "take into account the extent to which the applicant has avoided, minimized, and mitigated" any adverse effects and condition work as necessary to protect resource area values.

The MACC Model Bylaw contains a specific provision for the buffer zone (VII):

In reviewing activities within the buffer zone, the Commission shall presume the buffer zone is important to the protection of other resource areas because activities undertaken in close proximity have a high likelihood of adverse impact, either immediately, as a consequence of construction, or over time, as a consequence of daily operation or existence of the activities. These adverse impacts from construction and use can include, without limitation, erosion, siltation, increase in pollutants, loss of groundwater recharge, poor water quality, and loss of wildlife habitat. The Commission may establish, in its regulations, design specifications, performance standards, and other measures and safeguards, including setbacks, no-disturb areas, no-build areas, and other work limits for protection of such lands, including without limitation strips of continuous, undisturbed vegetative cover, unless the applicant convinces the Commission that the area or part of it may be disturbed without harm to the values protected by the bylaw.

Thus, the model bylaw anticipates regulations that may include specific setbacks as well as flexibility where disturbance will not cause an adverse effect. In their bylaw regulations, Commissions may choose to

include provisions for specific minor activities (see 310 CMR 10.02(2)(b)2. for examples) or an administrative review process for circumstances where impacts will be negligible.

MODEL REGULATIONS UNDER MACC MODEL BYLAW FOR ACTIVITIES IN THE BUFFER ZONE

Buffer Zones (insert into regulations with provisions for other resource areas; add definition of “Buffer Zone” and “structure” to definition section of regulations).

A. **Preamble.** Naturally vegetated Buffer Zones protect the adjacent resource areas by filtering and removing pollutants, by providing groundwater recharge, by maintaining surface and groundwater flows, by moderating water temperatures, by providing essential habitat for wetland wildlife and plant species, by providing shading and screening, by preventing or reducing erosion and siltation into wetlands, by providing flood storage capacity and associated prevention of pollution, and by protecting water quality. Activities undertaken in the Buffer Zone have a high likelihood of adverse impact to the adjacent resource area.

B. **Wetlands Values Protected.** Buffer Zones are presumed to be significant to erosion and sedimentation control, to prevention and control of pollution, to storm damage prevention and to the protection of water quality and wildlife habitat, as well as the protection of all resource area values identified in the bylaw that are associated with the adjacent resource area.

C. **Performance Standards.** The intent of the Bylaw and Regulations is to avoid, minimize, and mitigate alterations in the Buffer Zone, and to ensure that new land disturbance, structures, and activities are located as far as possible from resource areas, consistent with conditions at the site and the characteristics of the proposed work.

1. To the maximum extent possible, Buffer Zones shall be retained in a naturally vegetated condition. Where Buffer Zone disturbance is permitted, revegetation with native species may be required.
2. Work in the Buffer Zone shall not substantially alter the hydrology of the site, including runoff rates, volume, water quality, flood storage capacity or flow paths.
3. To the maximum extent possible, work shall be located away from the resource area.
4. Work in the Buffer Zone shall not impair critical wildlife habitat or any vernal pool habitat.
5. The use of herbicides, pesticides, fungicides, fertilizers or other chemical treatment constitutes an alteration of the Buffer Zone as defined in the Bylaw and thus is prohibited unless explicitly allowed by the Commission in an Order of Conditions.
6. The Commission may require the placement of permanent markers to establish the boundary of any limits to future alteration.
7. Work in Undeveloped Buffer Zones.
 - a. In an undeveloped Buffer Zone, no work shall be allowed within 25 ft. of the adjacent resource area, with the exception of work intended to support the protected values and interests, sufficiently minor work that will have no effect on the resource area, or water-dependent structures.
 - b. In an undeveloped Buffer Zone, no structures, roadways, driveways or surfaces shall be permitted within 50 ft. of the adjacent resource area.
 - c. Notwithstanding paragraphs (a) and (b) above, the Commission may permit limited and

unavoidable work in the Buffer Zone associated with construction of a structure crossing a wetland or stream, as long as all performance standards for work in the wetland or stream are met and work in the Buffer Zone is minimized and appropriately conditioned.

8. Work in Previously Developed Buffer Zones.
 - a. Where the Buffer Zone has been previously (i.e. before adoption of these regulations) altered within 50 ft. of the adjacent resource area, new development shall be located landward of existing development, unless the work will result in a net improvement to the capacity of the Buffer Zone to protect wetlands values.
 - b. Notwithstanding paragraph (a) above, the Commission may permit limited and unavoidable work in the Buffer Zone associated with construction of a structure crossing a wetland or stream, as long as all performance standards for work in the wetland or stream are met and work in the Buffer Zone is minimized and appropriately conditioned.

